

# **Evaluation of JPL Version-5.9.12 Temperature Profiles, Ocean Skin Temperature, Surface Emissivity, and Cloud Cleared Radiances**

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AIRS Science Team Meeting  
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# Outline

- Modifications to JPL 5.9.12 compared to V5.9.1 (July 28, 2011 Net Meeting)
- Some results showing that V5.9.12 O, with original water vapor sounding channels, is preferable to V5.9.12 N with Antonia Gambacorta's new water vapor channels

More comparisons are shown in back-up material

- Comparison of V5.9.12, V5.9.12 AO, V5.9.1, and V5.0

More comparisons of V5.9.12 with V5.9.12 AO are shown in back-up material

- Accuracy and yield of channel by channel Quality Controlled clear-column radiances  $\hat{R}_i$
- Plans for Version-7

# Changes Since Version 5.9.1 (July 2011)

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Updates to neural net first guess (Manning and Milstein)

- Improved interpolation near surface

- Better handling of sea ice

Modification to emissivity first guess and retrieval (Manning, Hulley, Blaisdell)

Changes to RTA for large solar zenith angles (Maddy)

Changes to cloud parameter retrievals (Manning, Blaisdell, Susskind)

- Neural net  $T_{\text{skin}}$  is used over ocean when retrieval is thought to be bad

Updated channel lists to remove channels bad by 2010 (Manning, Blaisdell)

Error estimates (Susskind, Iredell)

- Separate error coefficients are generated for polar cases

- New coefficients generated consistent with V5.9.12, V5.9.12 AO



# Comparison of Results Obtained Using V5.9.12 O and V5.9.12 N

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Version-5.9.12 O and V5.9.12 N are otherwise identical in every way except for use of a new set of water vapor sounding channels in V5.9.12 N as suggested by Antonia Gambacorta and co-workers

Use of new channels in current system improves some products but significantly degrades the accuracy of the water vapor profiles, especially for harder (cloudier) cases

In the absence of time for further optimization, we recommend use of the old channel set in Version-6. Further optimization should be done in Version-7

The next two charts show results related to water vapor profiles

Other comparisons are shown in the back-up material

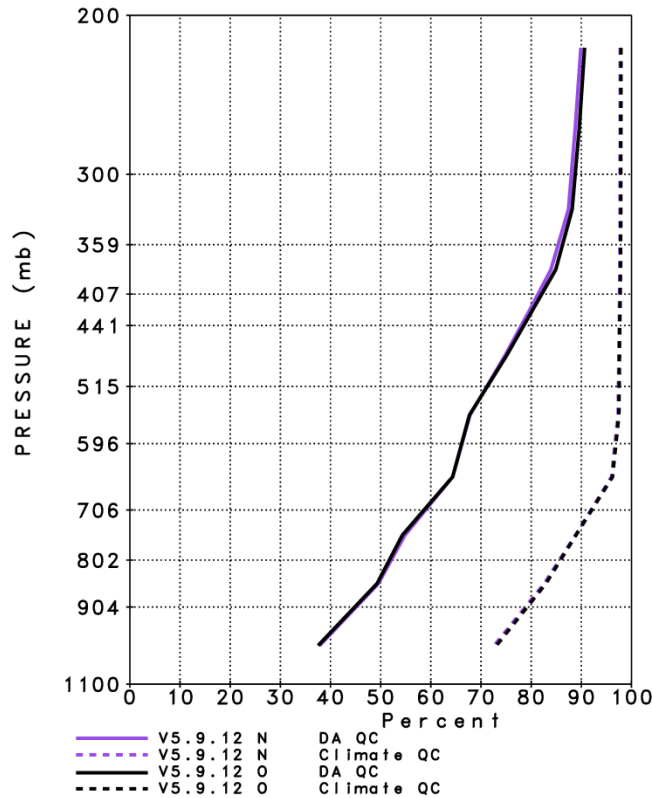
All further comparisons are V5.9.12 O, called V5.9.12



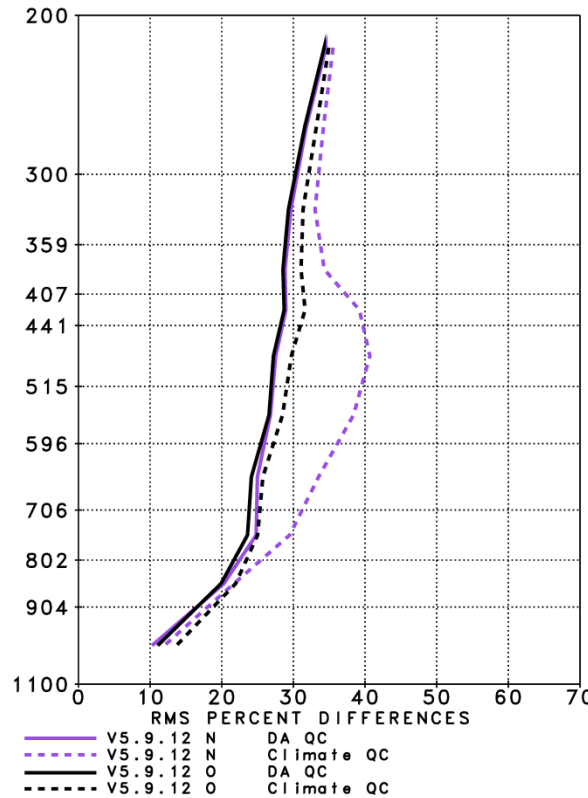


# Global 1 Km Layer Precipitable Water 7-Day

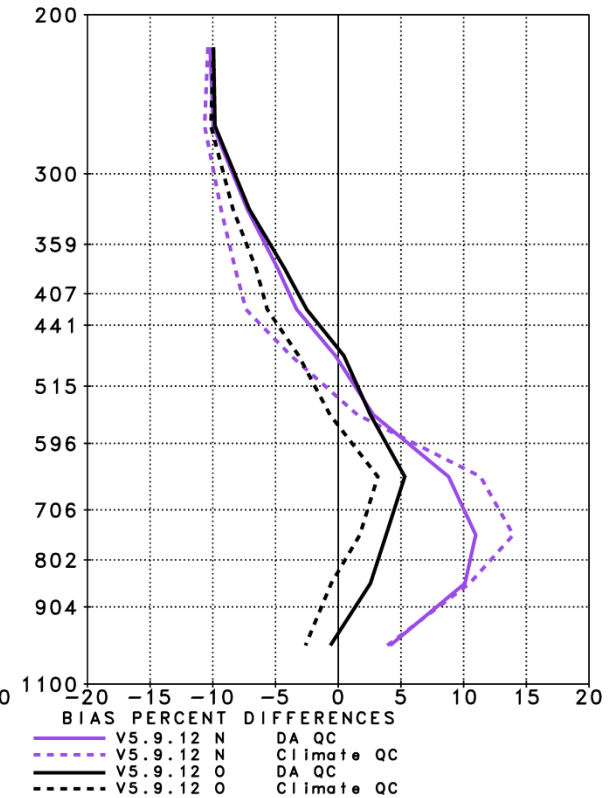
Percent Yield



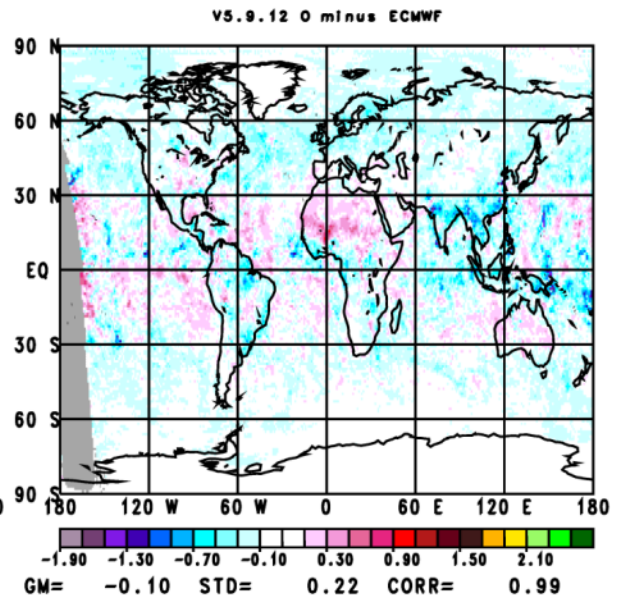
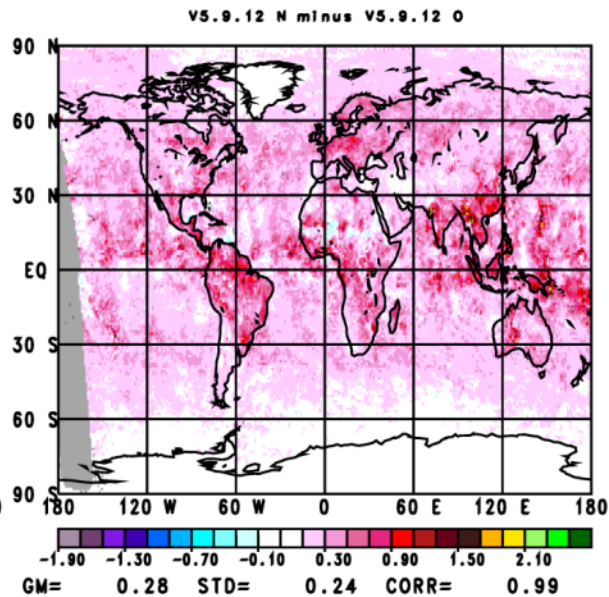
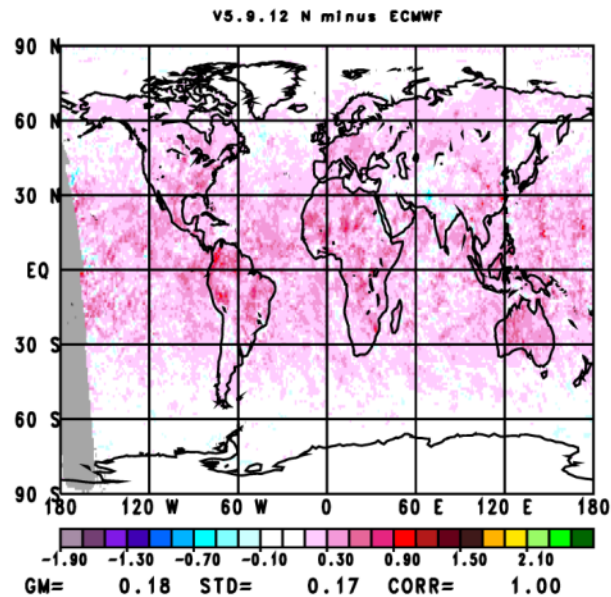
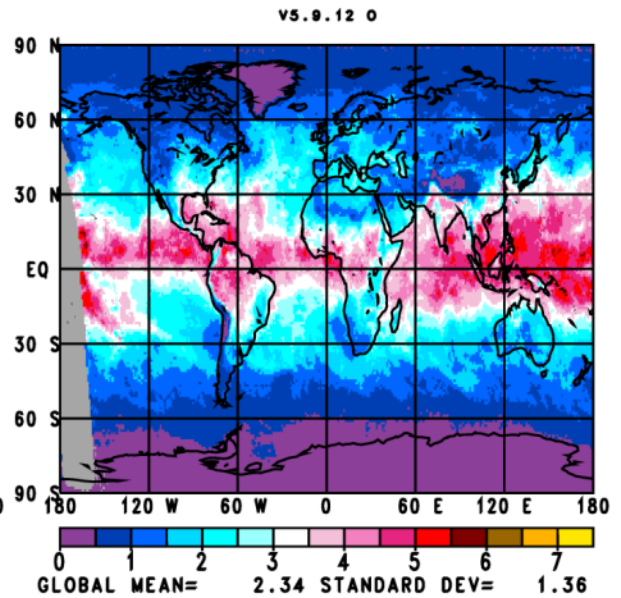
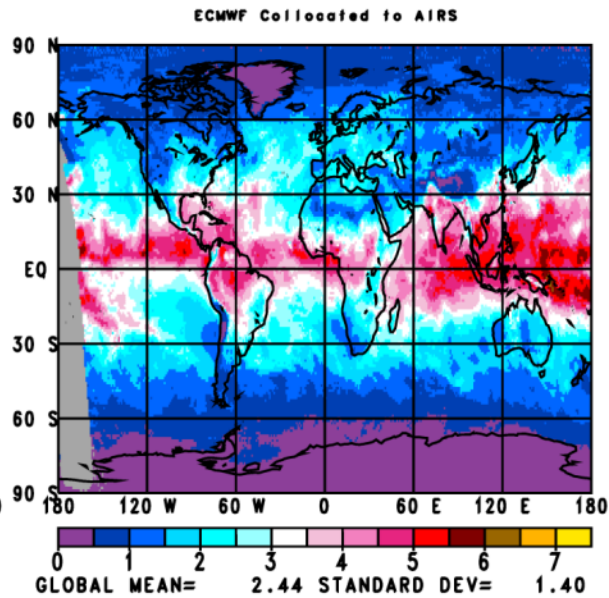
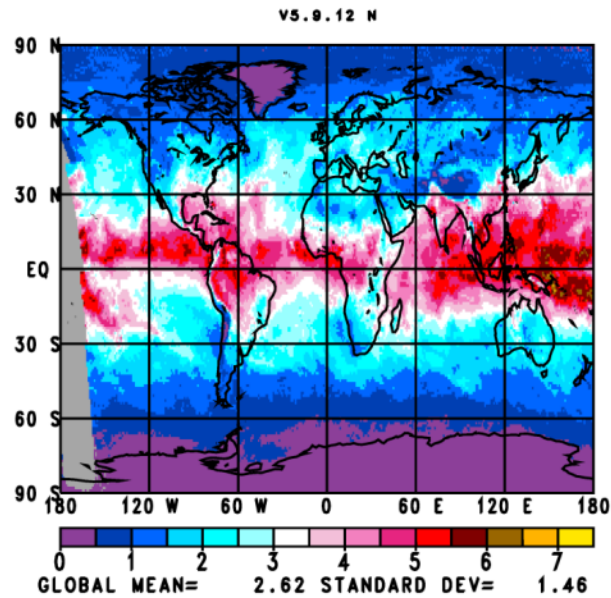
% Difference from ECMWF  
RMS



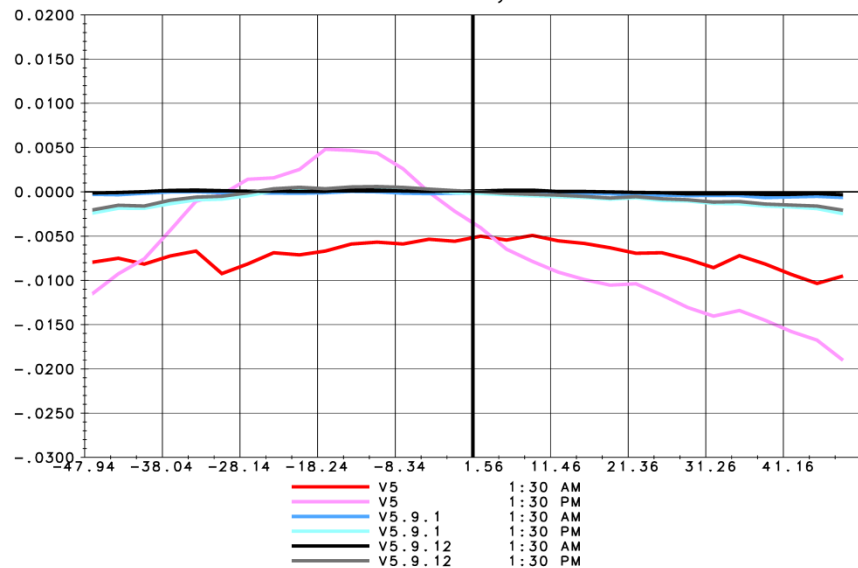
% Difference from ECMWF  
BIAS



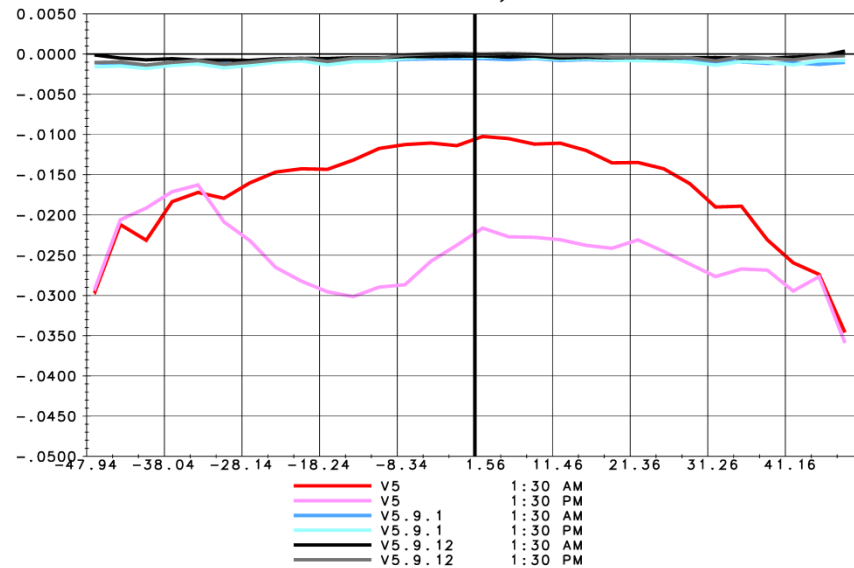
# 7-Day Total Precipitable Water (cm) 7-Days 1:30 PM New Water Channels vs Old Water Channels



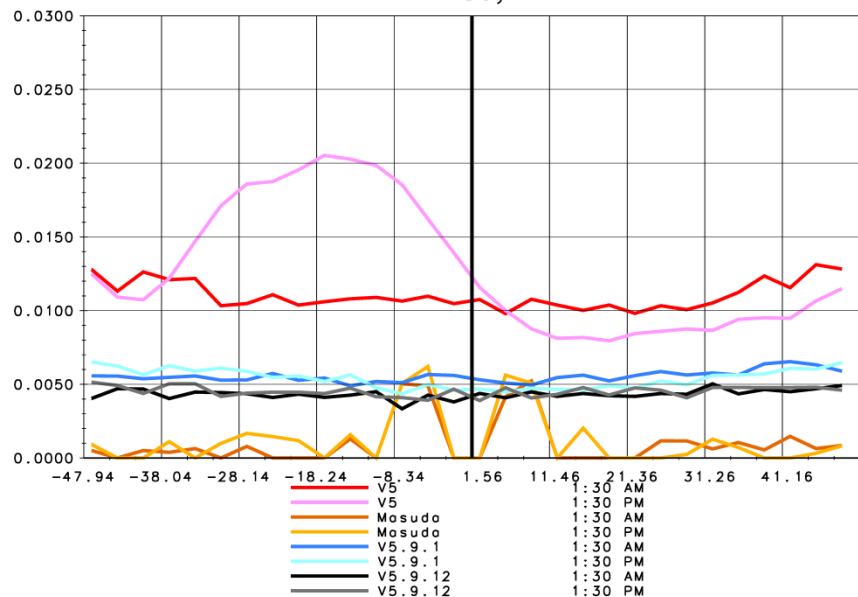
Mean 950  $\text{cm}^{-1}$  Emissivity minus Masuda  
50 North to 50 South Ocean  
7-Day



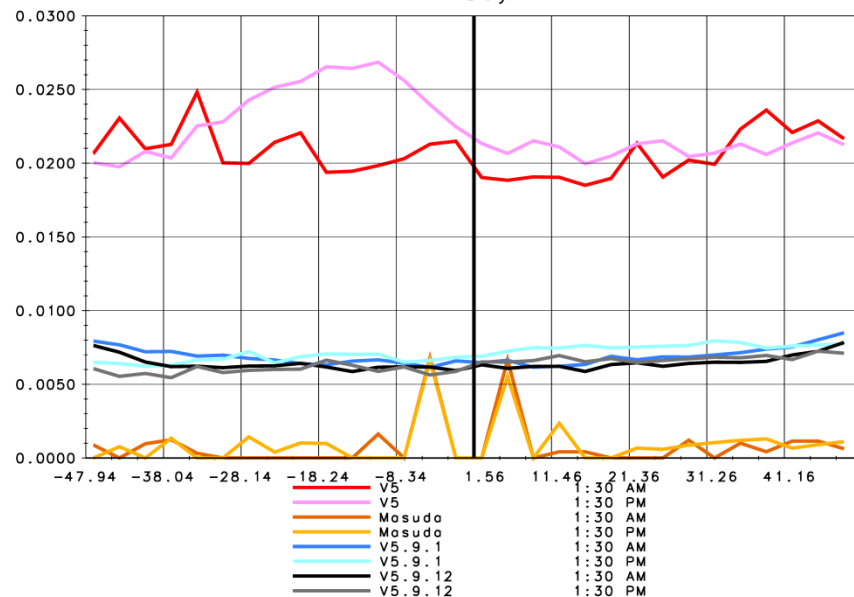
Mean 2400  $\text{cm}^{-1}$  Emissivity minus Masuda  
50 North to 50 South Ocean  
7-Day



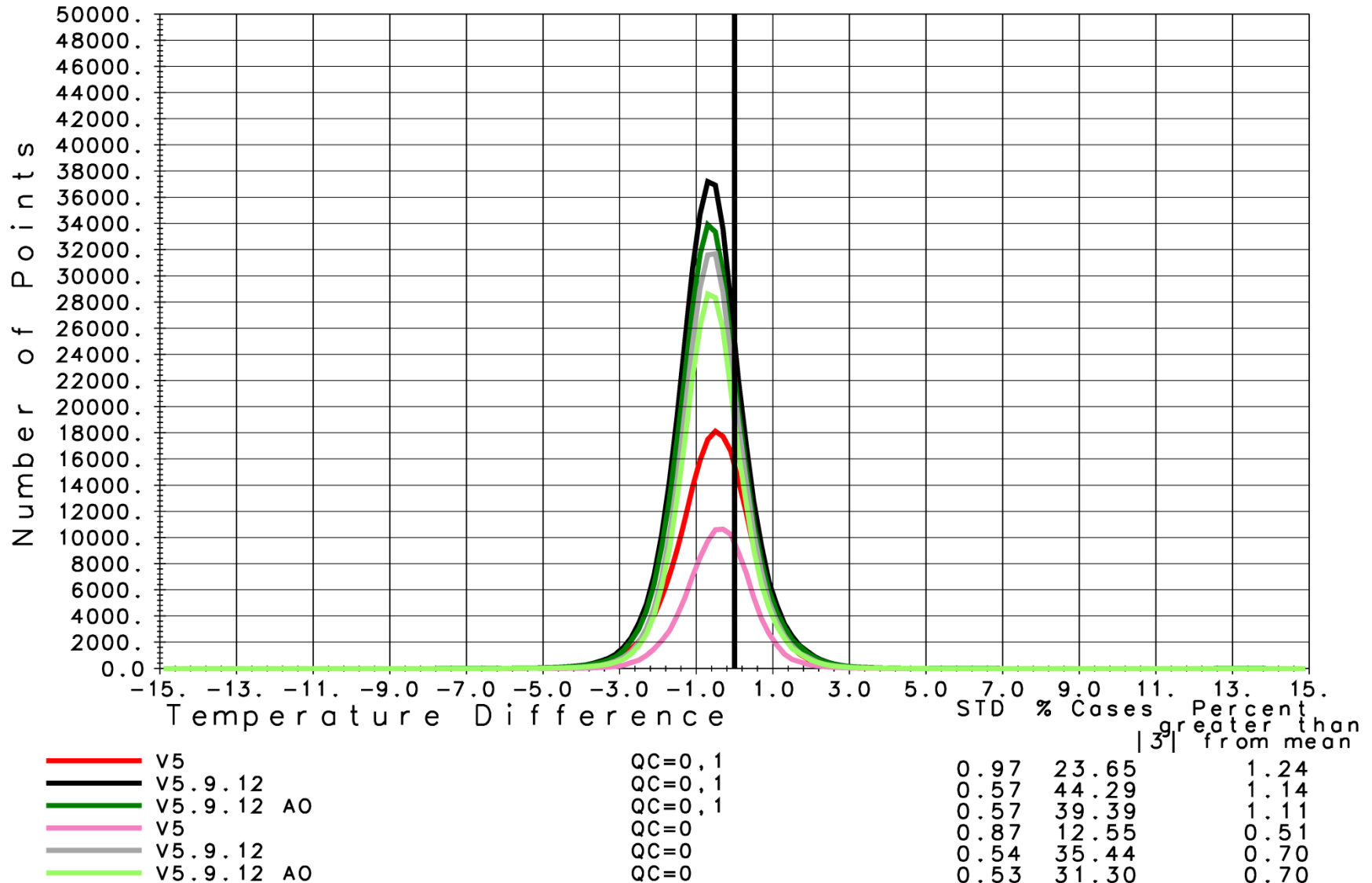
STD 950  $\text{cm}^{-1}$  Emissivity  
50 North to 50 South Ocean  
7-Day



STD 2400  $\text{cm}^{-1}$  Emissivity  
50 North to 50 South Ocean  
7-Day

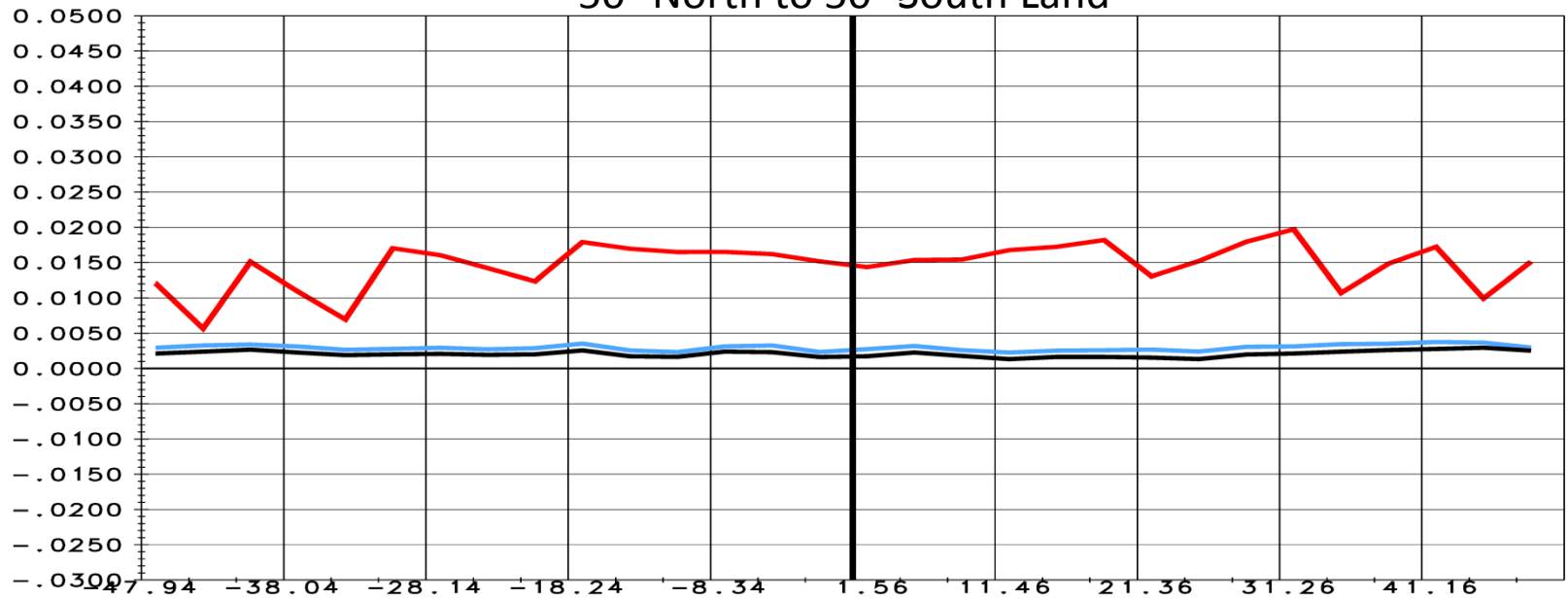


# Surface Skin Temperature Difference 7-Day Daytime and Nighttime combined 50 N to 50 S Non-Frozen Ocean

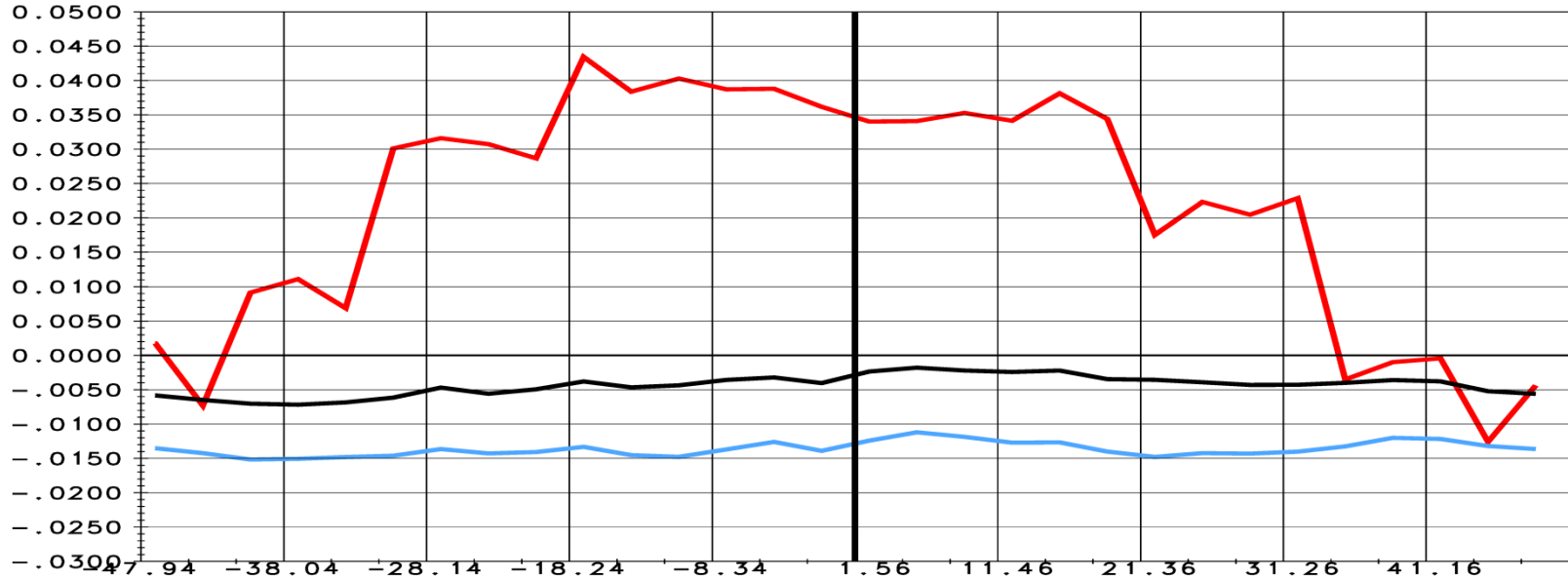


# Mean AM minus PM Emissivity 7-Day Average 50° North to 50° South Land

950 cm<sup>-1</sup>



2400 cm<sup>-1</sup>



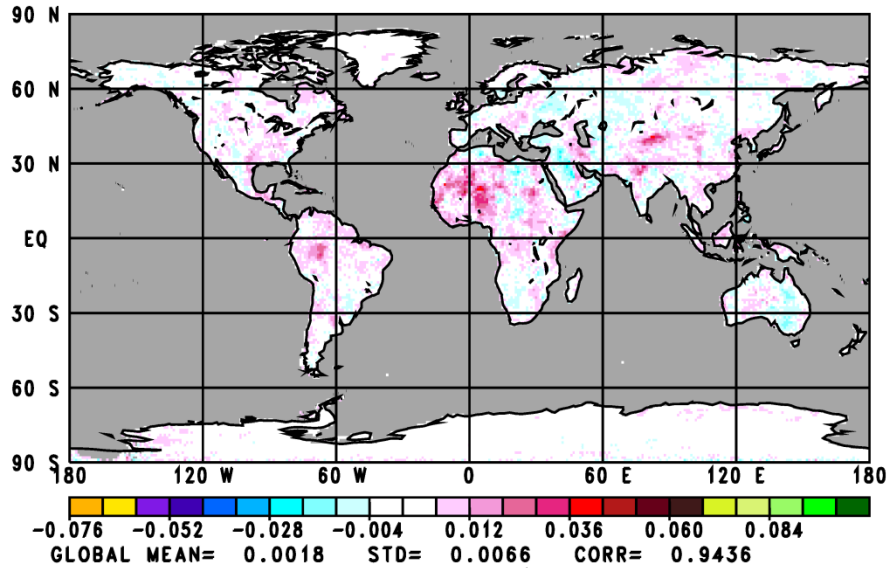
V5  
V5.9.1  
V5.9.12



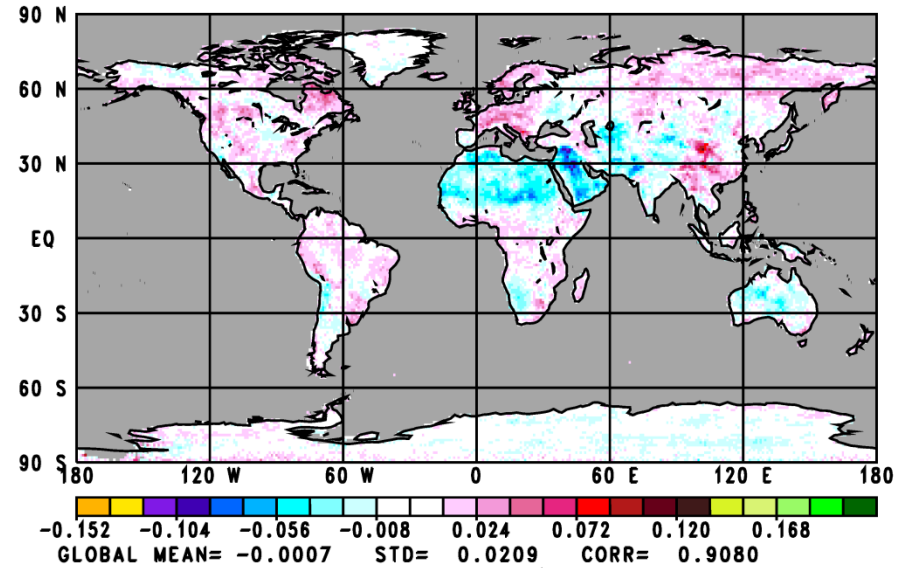


7-Day  
AIRS IR Emissivity  
1:30 AM minus 1:30 PM

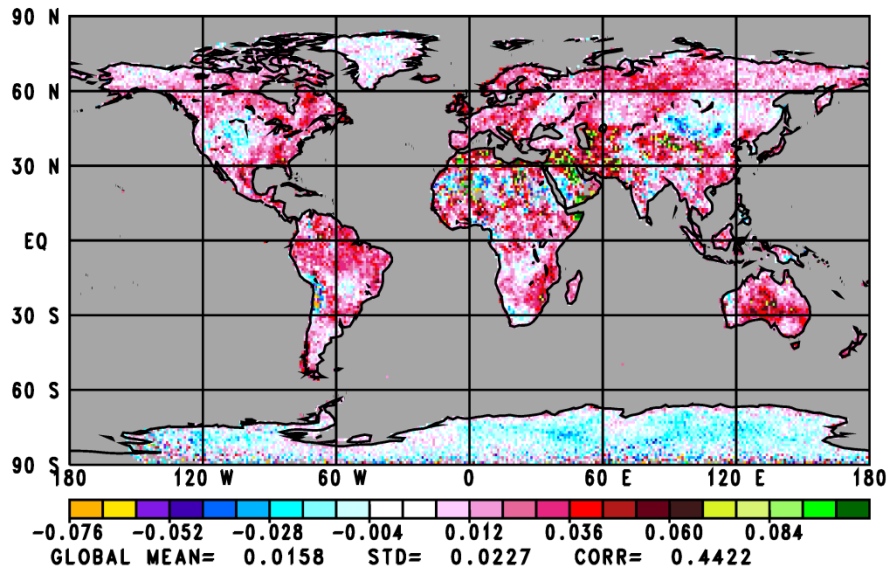
950  $\text{cm}^{-1}$   
V5.9.12



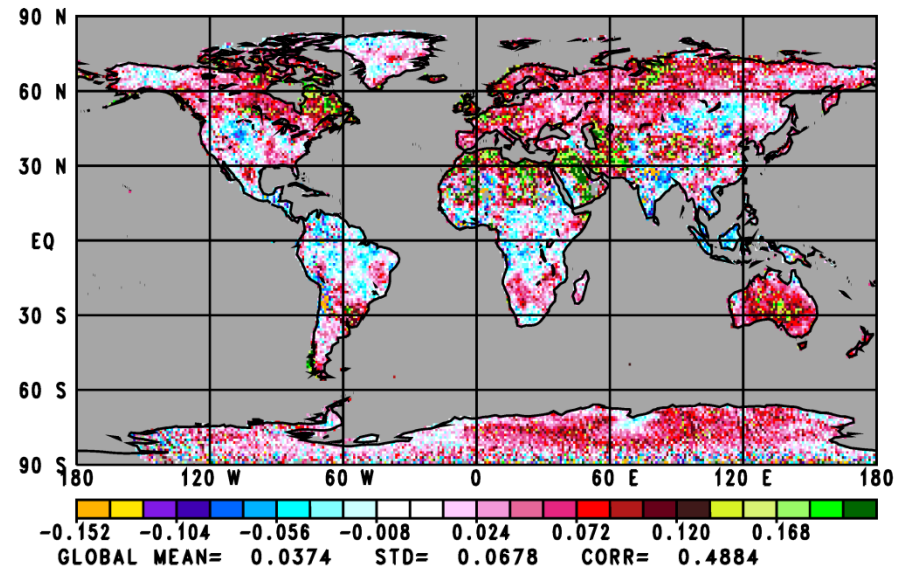
2400  $\text{cm}^{-1}$   
V5.9.12



950  $\text{cm}^{-1}$   
V5

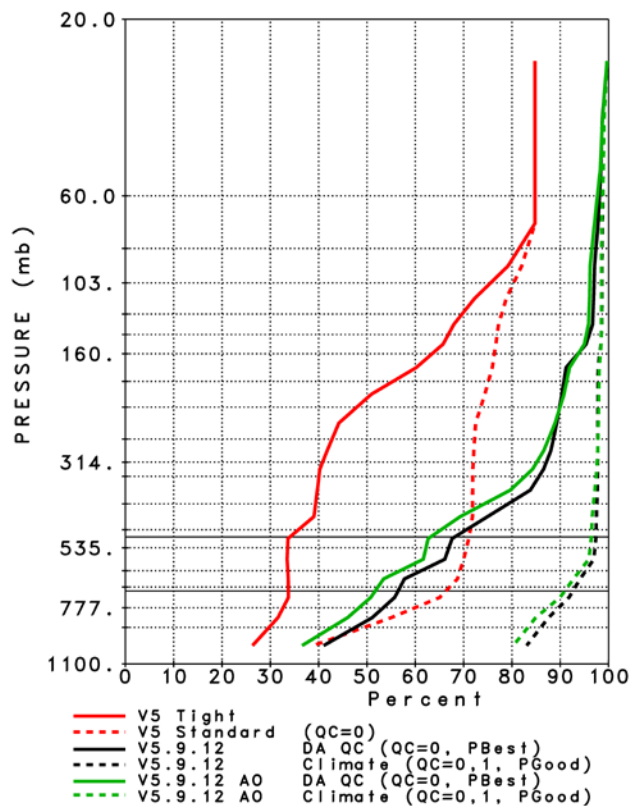


2400  $\text{cm}^{-1}$   
V5

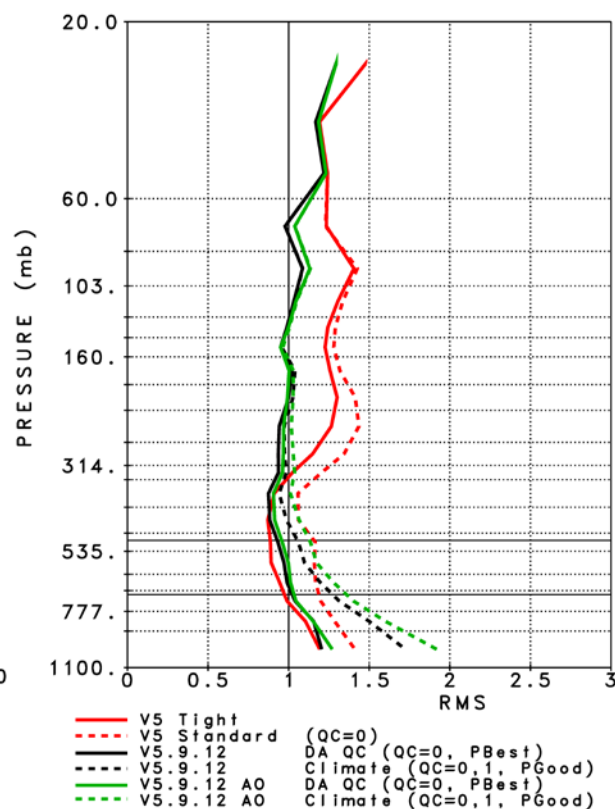


# Global Temperature 7-Day Statistics use their own QC

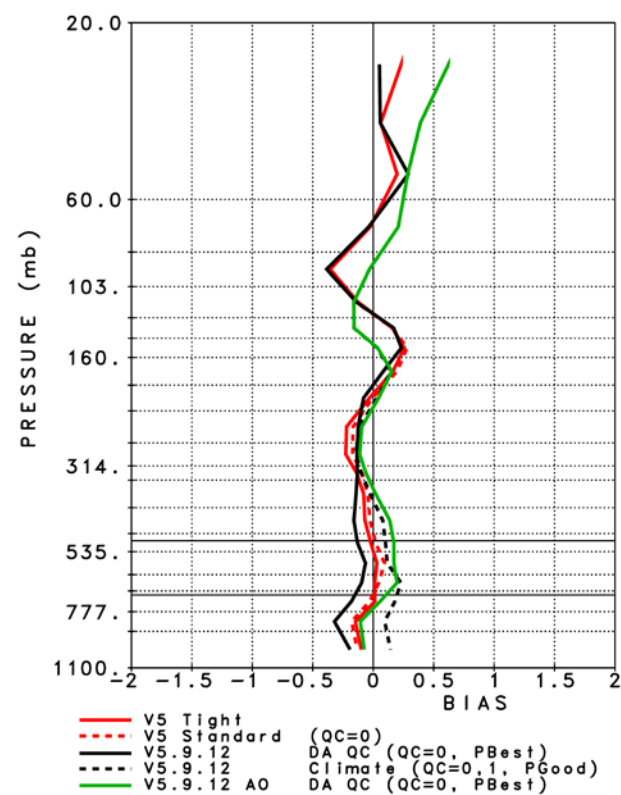
Percent of All Cases Accepted



Layer Mean RMS ( $^{\circ}$ K)  
Differences from ECMWF

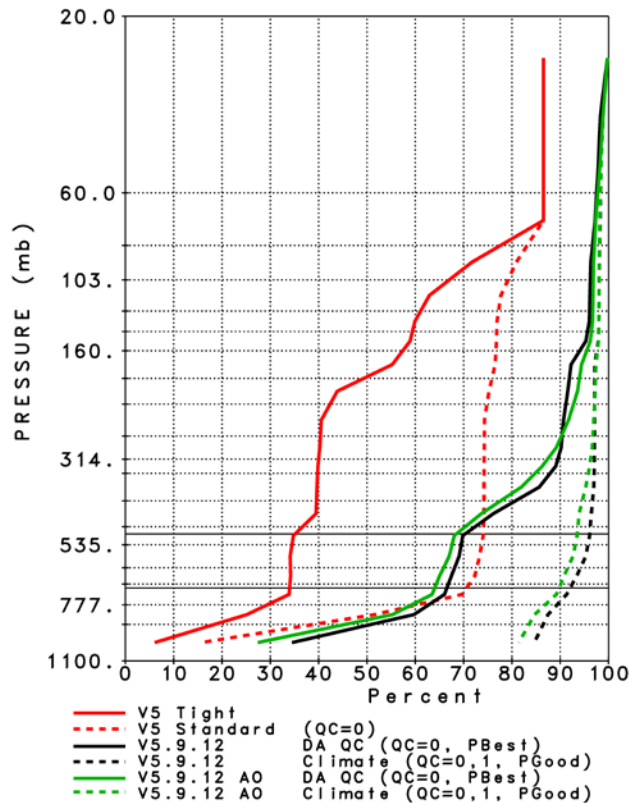


Layer Mean BIAS ( $^{\circ}$ K)  
Differences from ECMWF

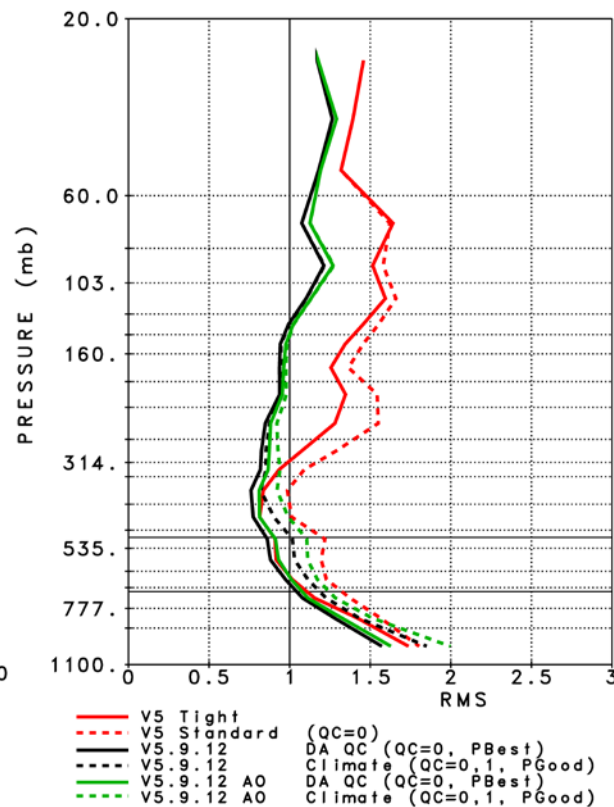


# 50° North to 50° South Land Temperature 7-Day Statistics use their own QC

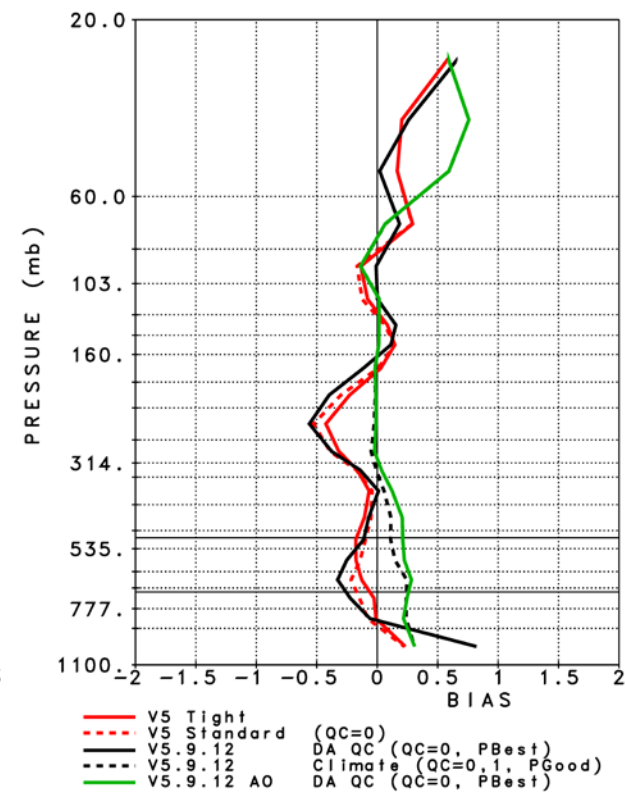
Percent of All Cases Accepted



Layer Mean RMS ( $^{\circ}\text{K}$ ) Differences from ECMWF



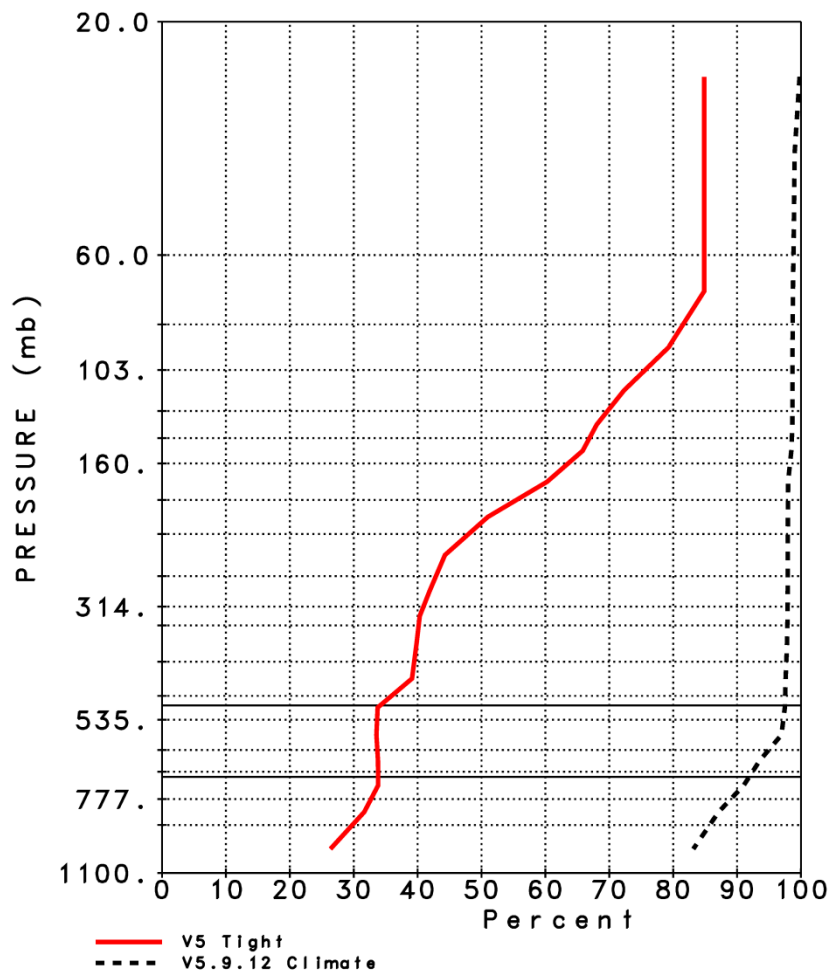
Layer Mean BIAS ( $^{\circ}\text{K}$ ) Differences from ECMWF



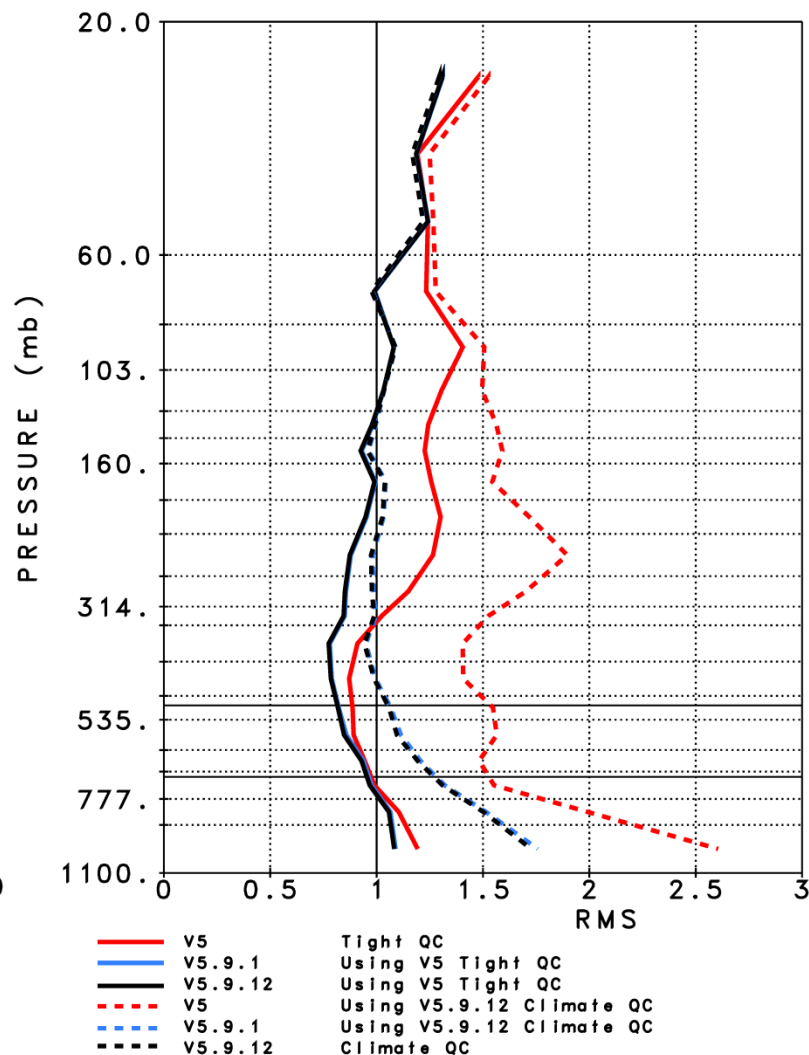


# Global Temperature Statistics for two Identical Ensembles 7-Day

Percent of All Cases  
Accepted



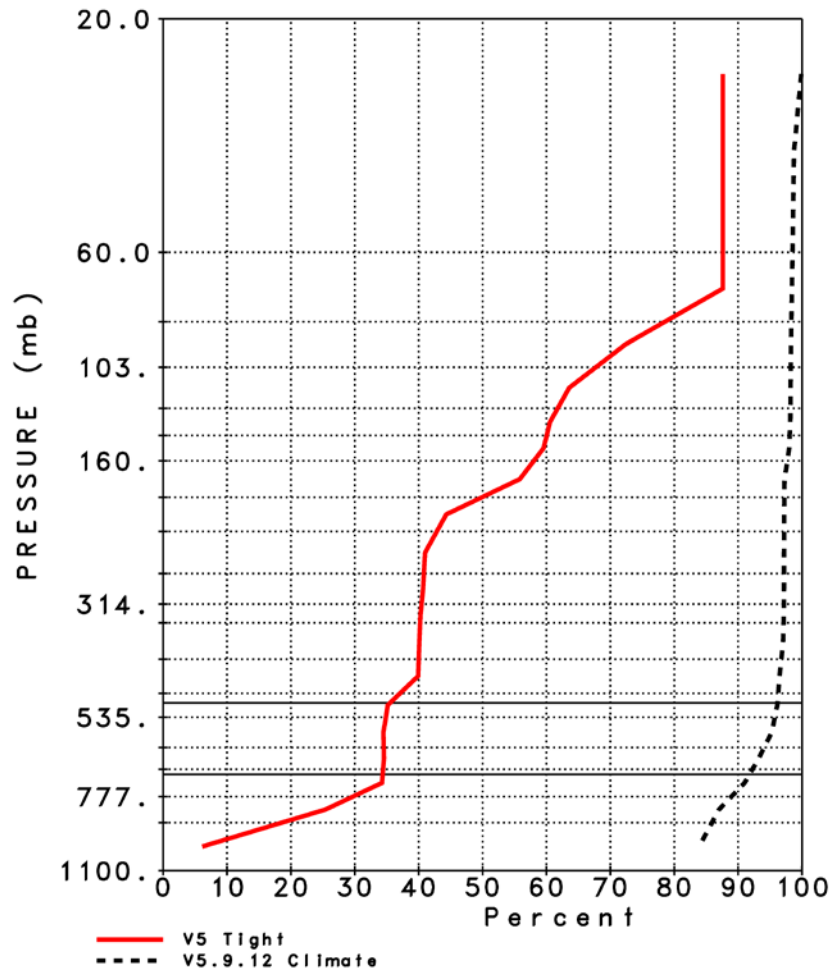
Layer Mean RMS ( $^{\circ}$ K)  
Differences from ECMWF



# 50° North to 50° South Land Temperature Statistics for two Identical Ensembles 7-Day

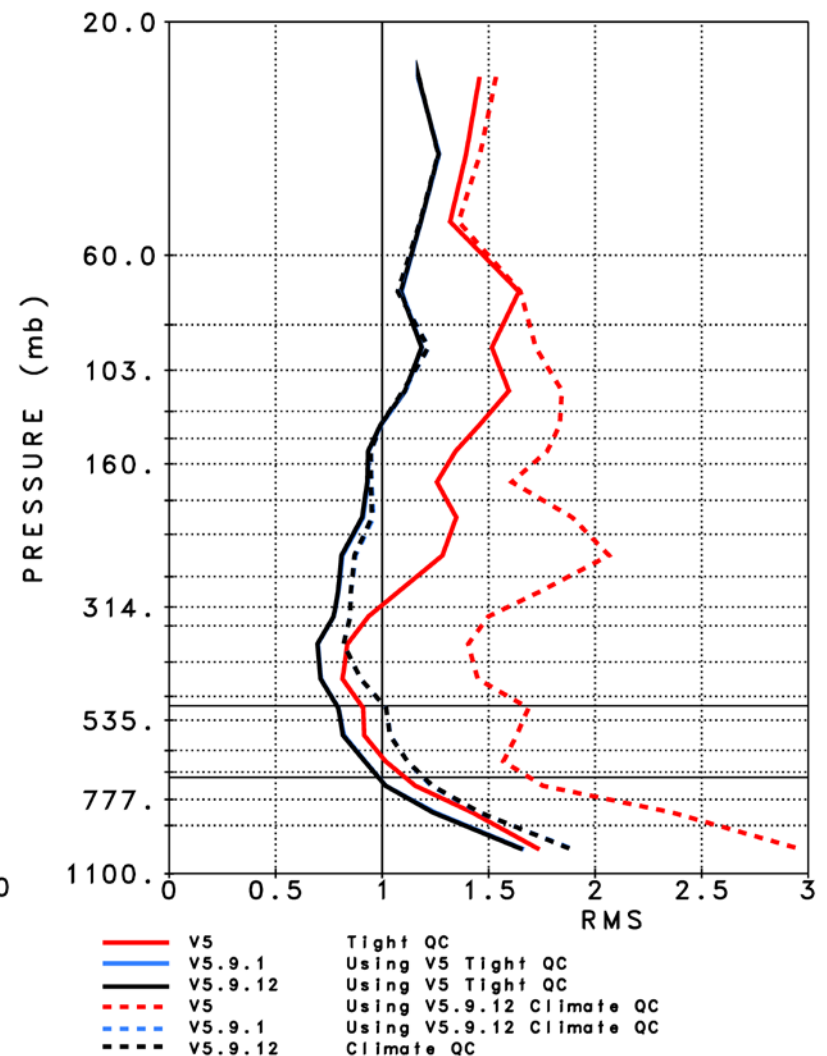
Percent of All Cases

Accepted



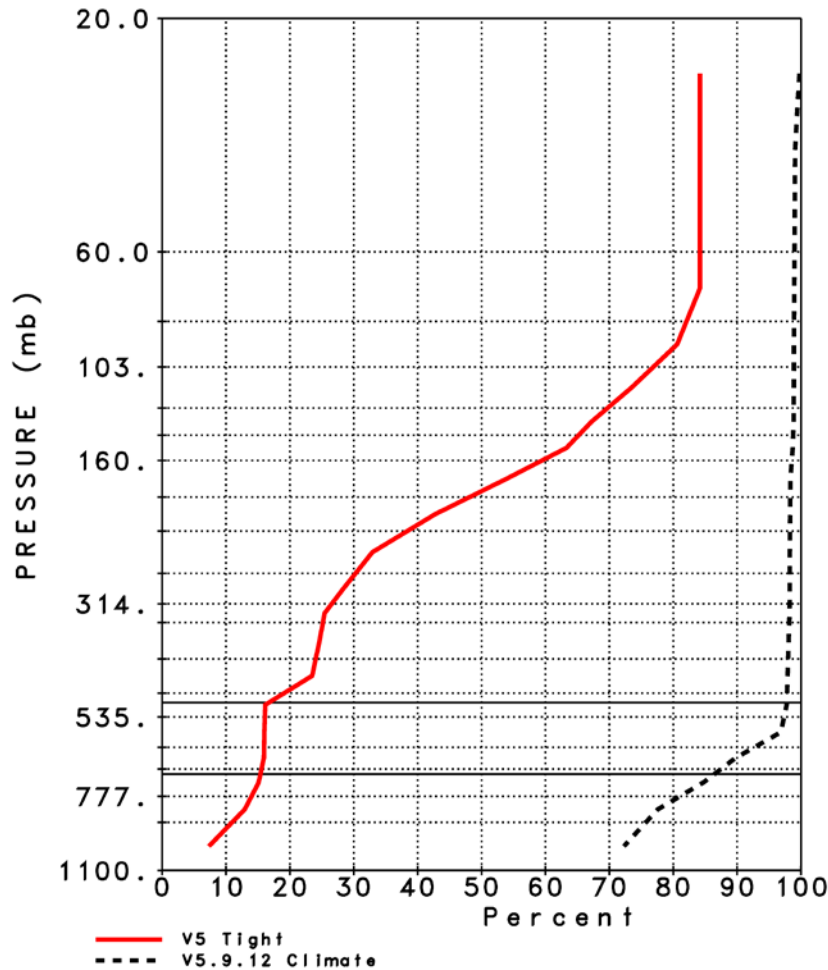
Layer Mean RMS (°K)

Differences from ECMWF

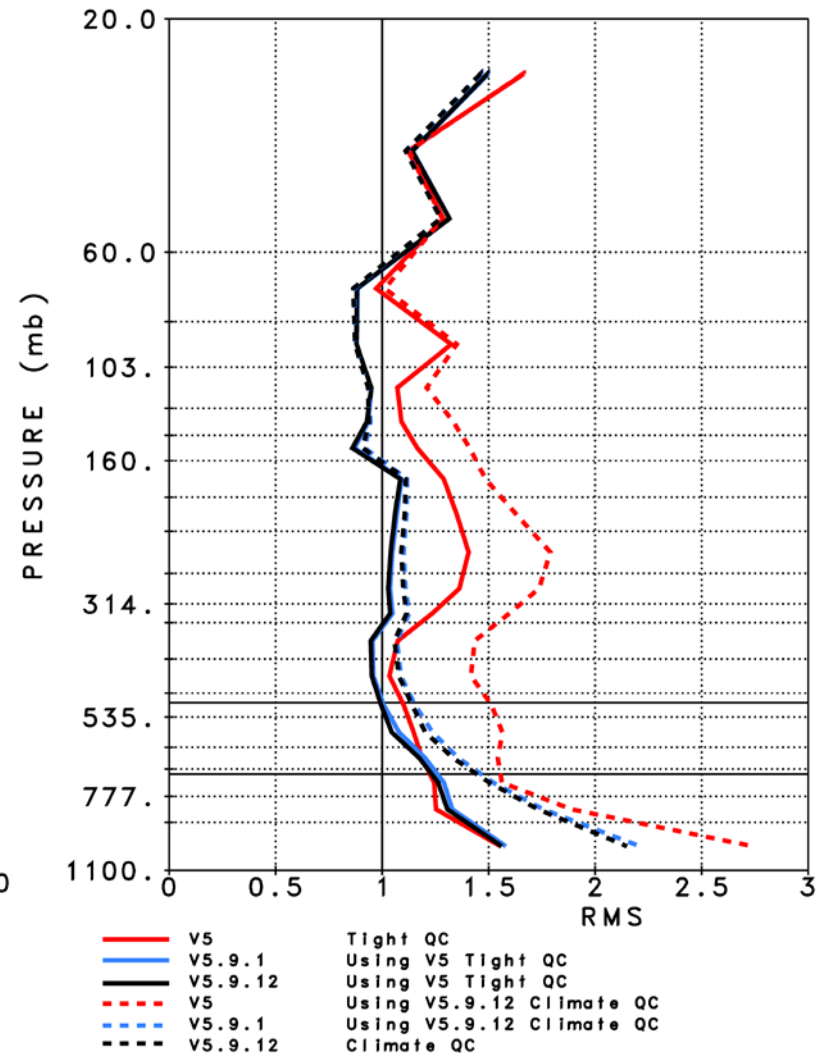


# Poleward of 50° Temperature Statistics for two Identical Ensembles 7-Day

Percent of All Cases  
Accepted



Layer Mean RMS (°K)  
Differences from ECMWF



# 7-Day Mean Statistics Tropospheric Temperature Metric (TTM) and Boundary Layer Metric (BLM)

## Cases in Common Using the Version-5 Tight Ensemble

	<u>Global</u>		<u>Land <math>\pm 50^\circ</math></u>		<u>Ocean <math>\pm 50^\circ</math></u>		<u>Poleward of <math>50^\circ\text{N}</math></u>		<u>Poleward of <math>50^\circ\text{S}</math></u>	
	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>
Version-5	1.10	1.29	1.19	1.71	1.04	1.13	1.14	1.50	1.31	1.76
V5.9.1	0.92	1.17	0.95	1.50	0.86	0.99	0.98	1.53	1.21	1.72
V5.9.12	0.92	1.16	0.94	1.49	0.86	0.98	0.96	1.47	1.20	1.69
V5.9.12 AO	0.94	1.30	0.98	1.63	0.88	1.13	0.98	1.64	1.22	1.82

## Cases in Common Using the 5.9.12 Climate Ensemble

	<u>Global</u>		<u>Land <math>\pm 50^\circ</math></u>		<u>Ocean <math>\pm 50^\circ</math></u>		<u>Poleward of <math>50^\circ\text{N}</math></u>		<u>Poleward of <math>50^\circ\text{S}</math></u>	
	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>
Version-5	1.66	2.53	1.82	2.75	1.64	2.43	1.52	2.35	1.71	2.70
V5.9.1	1.12	1.88	1.06	1.92	1.03	1.44	1.14	2.24	1.33	2.33
V5.9.12	1.11	1.85	1.06	1.90	1.02	1.40	1.12	2.15	1.32	2.28
V5.9.12 AO	1.18	2.10	1.14	2.10	1.08	1.64	1.18	2.45	1.43	2.63

# Comparison Summary

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JPL Version-5.9.12 is significantly improved compared to Version-5 with regard to temperature profiles, ocean skin temperature, and surface emissivities

- T(p) is slightly improved compared to Version-5.9.1
- Land surface emissivity is somewhat improved compared to Version-5.9.1 especially in the shortwave

Version-5.9.12 AO performs only slightly poorer than Version-5.9.12  
Comparisons of some Level 3 spatial plots are shown in back-up material

Agreement of all fields shown in backup is very good

Version-5.9.12 retrieval system is ready for use in Version-6  
Some work still needed for error estimates and QC for clear column radiances



# Clear Column Radiance Error Estimates $\hat{\partial R}_i$

$$\hat{R}_i = \bar{R}_i + \sum_{k=1,9} n_k (R_{i,k} - \bar{R}_i) \quad \text{channel}_i, \text{FOV}_k$$

$\hat{R}_i$  has two sources of error: instrument noise  $NE\Delta N_i$  and error due to cloud clearing  $CCE_i$

The instrument noise  $NE\Delta N_i$  is amplified by taking a linear combination of  $R_{i,k}$  to get  $\hat{R}_i$

Instrument noise contribution is given by  $A$  times  $NE\Delta N_i$  where  $A$  is the noise amplification factor

$A$  increases with  $\eta_k$  and is typically greater than 1

Special case: channel <sub>$i$</sub>  does not see clouds in this scene  $A_{i,clear} = 1/3$

We parameterize the cloud clearing error for a given channel and sounding as

$$CCE_i = \sum_{j=1}^6 B_{i,j} \partial T_j \quad \text{where } \partial T_j \text{ is the error estimate for } T_j$$

$B_{ij}$  are error estimate coefficients

$$\partial \hat{R}_i \text{ is expressed as } \partial \hat{R}_i = [(A_i NE\Delta N_i)^2 + CCE_i^2]^{1/2}$$

$\partial \hat{\Theta}_i$  is the equivalent error estimate in brightness temperature units

# Need for $\partial \hat{R}_i$ and Error Flags

- 1)  $\hat{R}_i$  is a derived product and therefore requires an uncertainty and an error flag
- 2) Operational agencies currently assimilate AIRS  $R_i$  for channels unaffected by clouds

Primarily stratospheric channels in  $15\mu m$  CO<sub>2</sub> band

The spatial coverage is very poor for tropospheric sounding channels

Assimilating Quality Controlled values of  $\hat{R}_i$  is potentially a much better approach with better spatial coverage

To do this optimally,  $\partial \hat{R}_i$  and QC flags must be taken into account.

# QC Flags

## Current QC approach at SRT

QC = 0 if  $\partial \hat{\Theta}_i < 0.8 \text{ K}$       QC=0 is suitable for Data Assimilation

QC = 1 if  $0.8 \text{ K} < \partial \hat{\Theta}_i < 2.5 \text{ K}$

QC = 2 otherwise

We generated coefficients  $B_{i,k}$  based on Version-5.49 at SRT – two regression system

There are 6 sets of  $B_{i,k}$ : non-frozen ocean; land; and sea ice/snow covered land; with separate coefficients for day and night

John Blaisdell implemented the code to generate  $\partial \hat{R}_i$  and QC flags at JPL using Version-5.49 values of  $B_{i,k}$

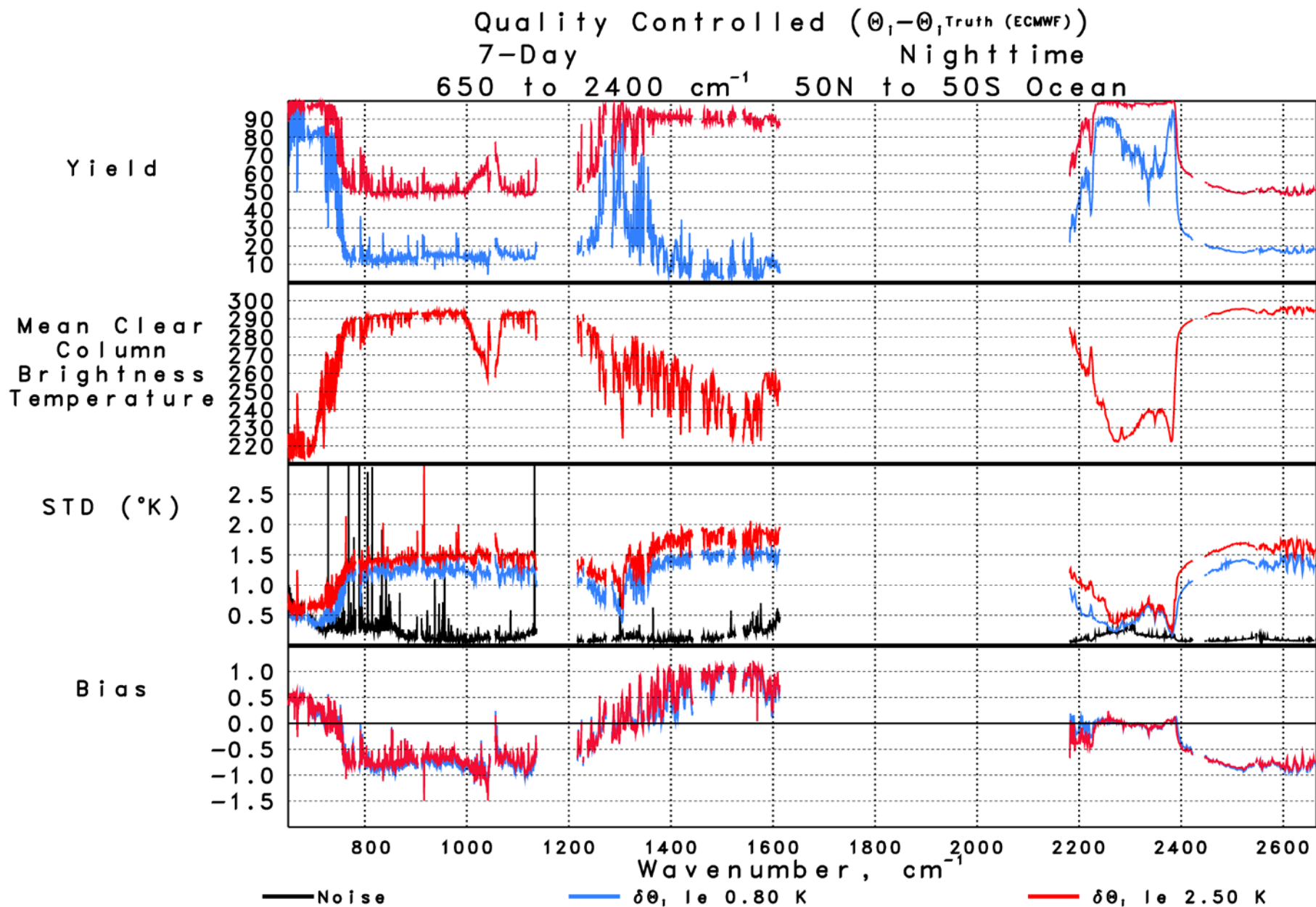
The code is not yet working correctly at JPL

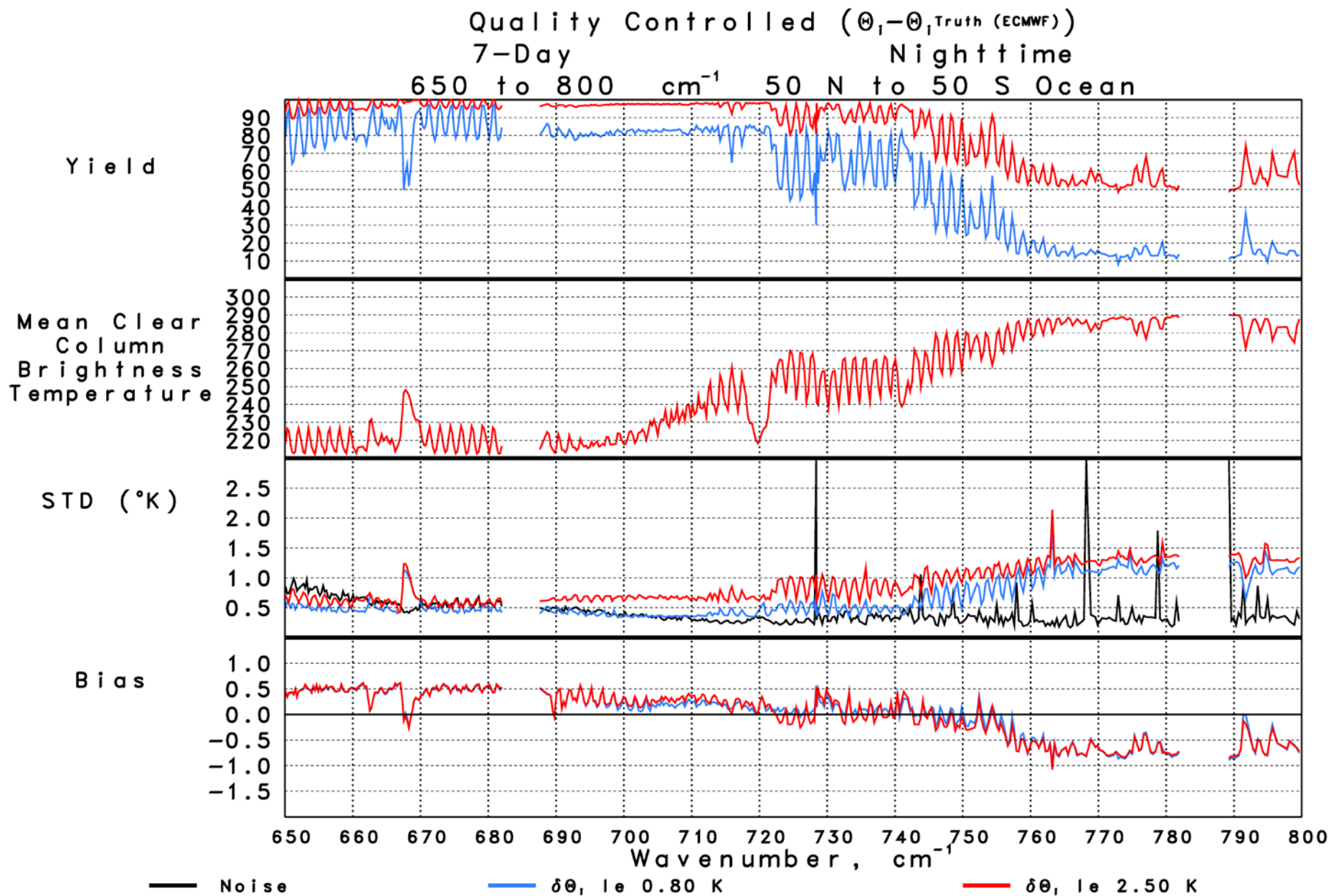
This should not affect any other results of the system

Next set of results shows QC controlled Version-5.49  $\hat{R}_i$

Statistics should be even better using Neural-Net because cloud clearing is better with Neural-Net







# SRT Plans for Completion of Version-6

## Necessary Research

Implement code to generate  $\partial \hat{R}_i$  and QC flags correctly at JPL

Generate  $B_{i,j}$  coefficients and optimize QC threshold for  $\hat{R}_i$   
based on results run at JPL

## Desirable Research

Optimize Version-6 Climate QC thresholds for all parameters based  
on 1 month runs done at JPL

Fix any possible glitches in the processing system found in JPL  
Version-6 testing

# Short Term SRT Plans for Version-7

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Implement Neural-Net start-up option at SRT

This is critical for optimal development and testing of further improvements

Improve water vapor retrieval using Neural-Net start-up: channels, functions, damping parameters

Improve temperature profile retrieval by using tropospheric  $15\ \mu\text{m}$   $\text{CO}_2$  channels that do not see clouds.

Theory says that  $15\ \mu\text{m}$   $\text{CO}_2$  channels that see clouds should not be used in T(p) retrieval. Version-6 assures this by using only stratospheric sounding  $\text{CO}_2$  channels

Many tropospheric  $15\ \mu\text{m}$  do not see clouds depending on the scene

# Longer term SRT Plans for Version-7

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Implement 1 (cross track) x 3 (along track) FOV retrieval system

This triples the spatial resolution of the AIRS soundings

Approach was attempted for Version-6, but dropped because soundings degraded in harder cloud cases

Version-6 Neural-Net start-up allows for much better sounding at cloudier cases

Attempt to include absorption by dust in the retrieval process

This should improve retrievals in dusty scenes rather than (hopefully) rejecting them as done now

Any other ideas that come up by us or other team members



# Back-up Material

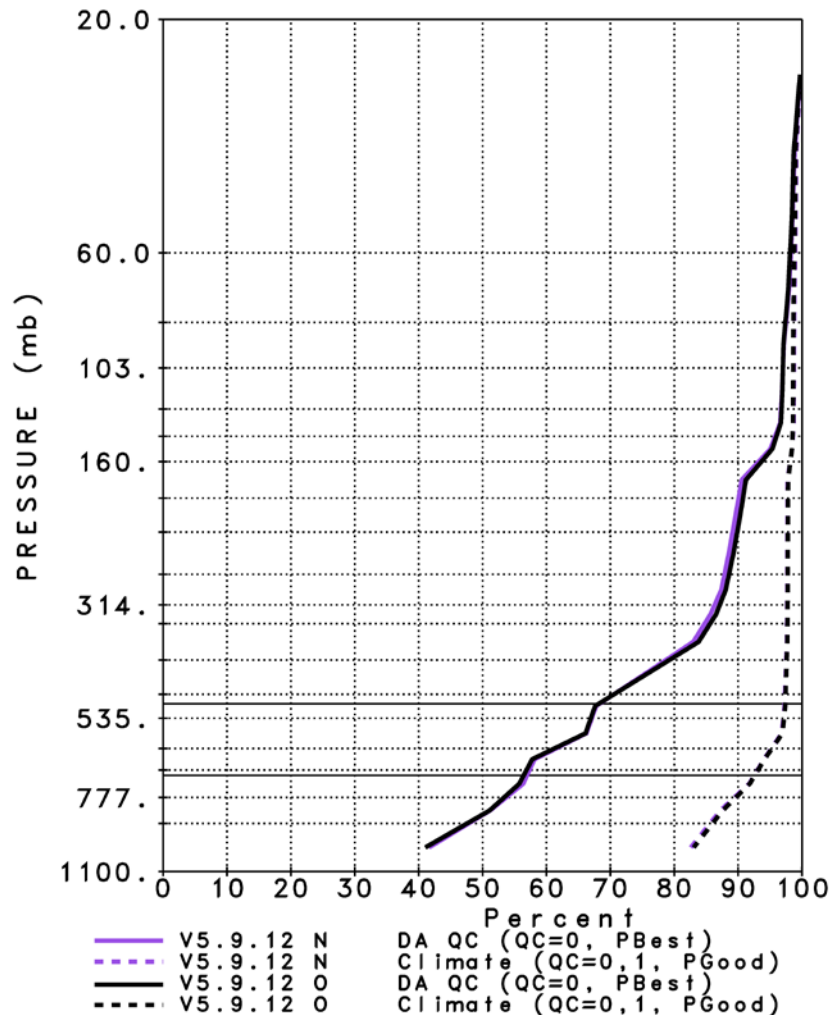
## New Water Vapor Channels

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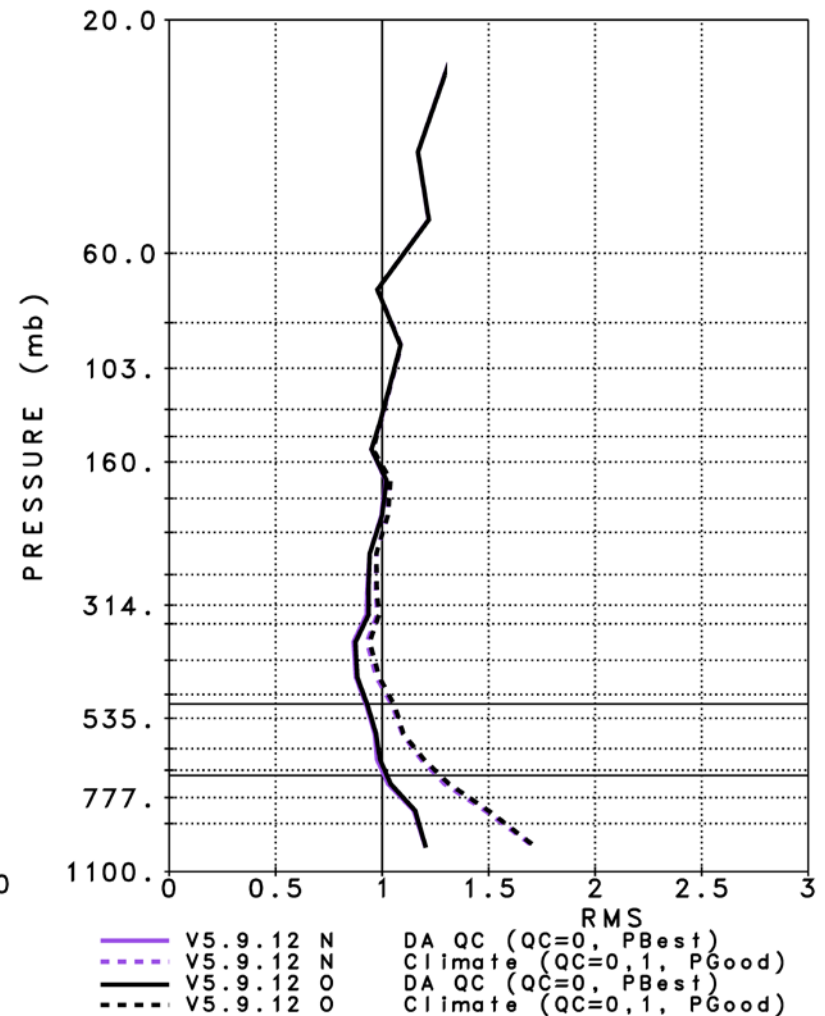
- T(p) results using new and old water vapor channels are comparable
- SST is degraded somewhat using new water vapor channels
- Day/night differences of total methane are smaller (better?) over Northern Hemisphere land using new water vapor channels

# Global Temperature Old and New Water Channels 7-Day

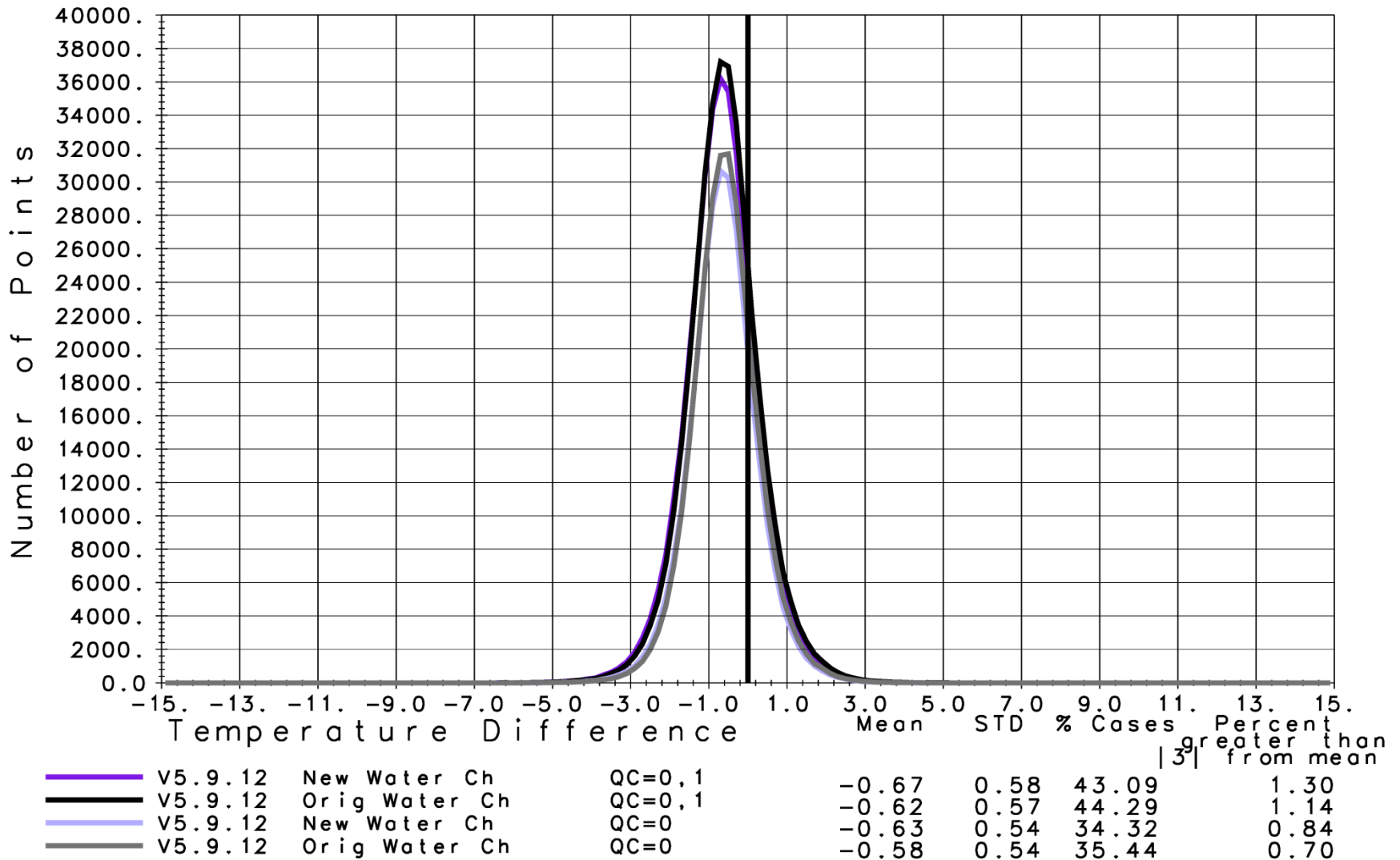
Percent of All Cases  
Accepted



Layer Mean RMS ( $^{\circ}\text{K}$ )  
Differences from ECMWF



Surface Skin Temperature Difference  
7-Day Daytime and Nighttime combined  
50 N to 50 S Non-Frozen Ocean

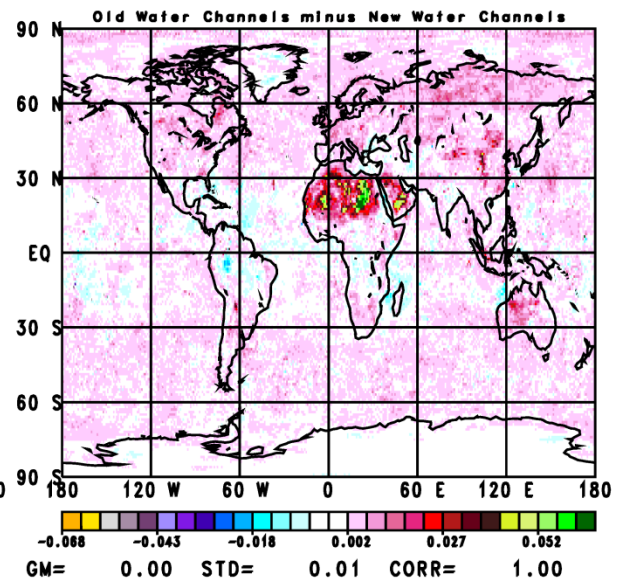
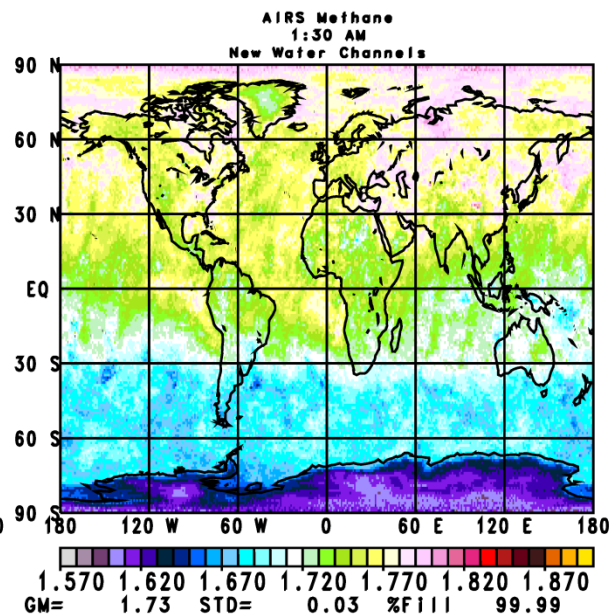
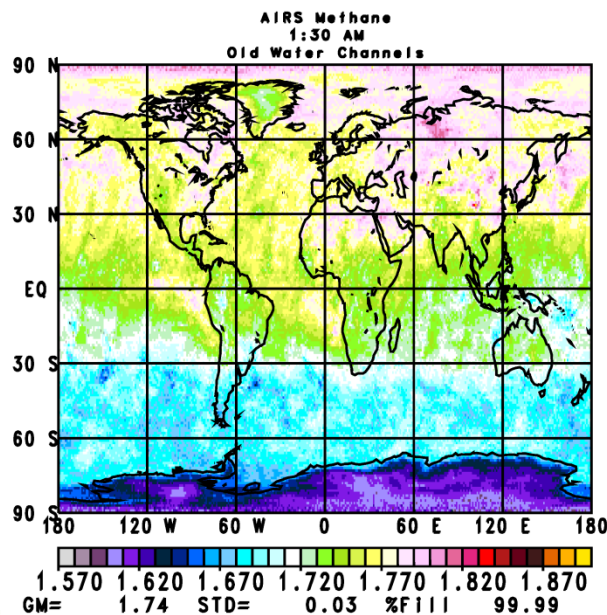
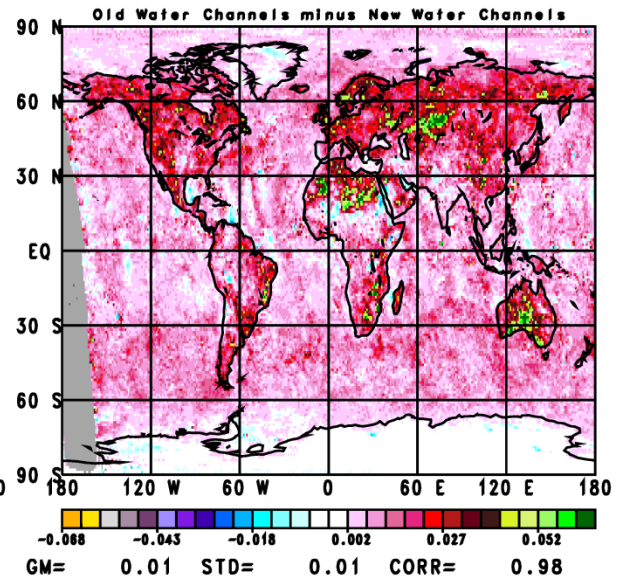
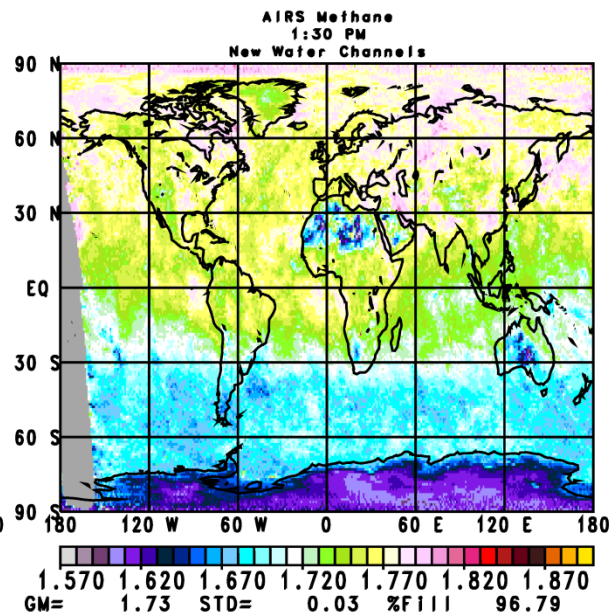
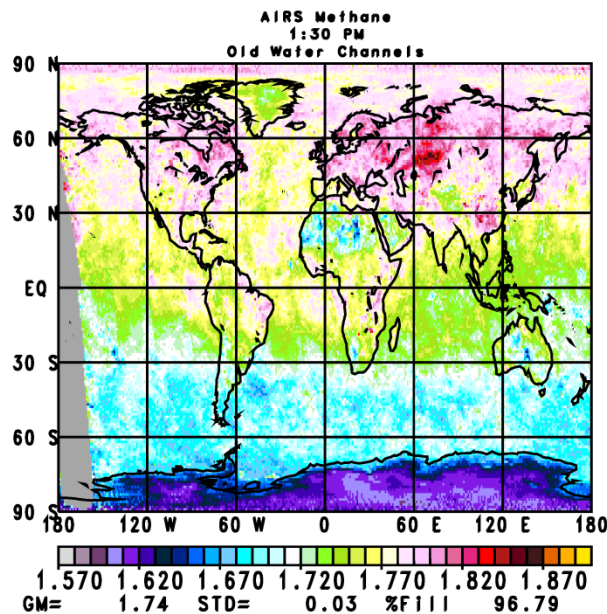




# Trace Gases Methane V5.9.12

## 7-Days

### Old Water Channels vs New Water Channels



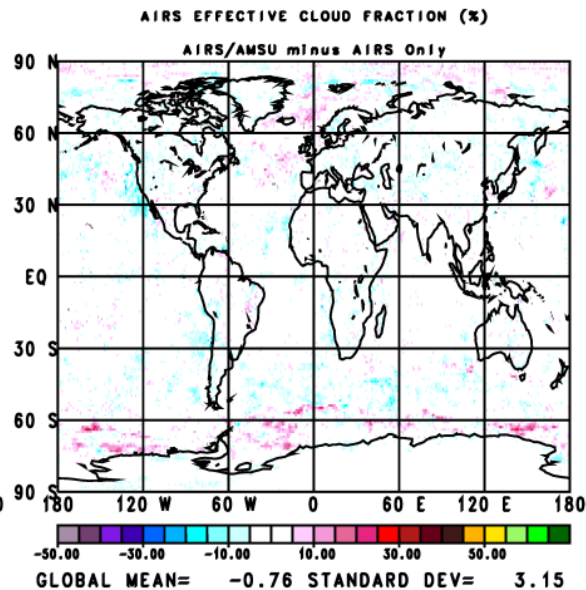
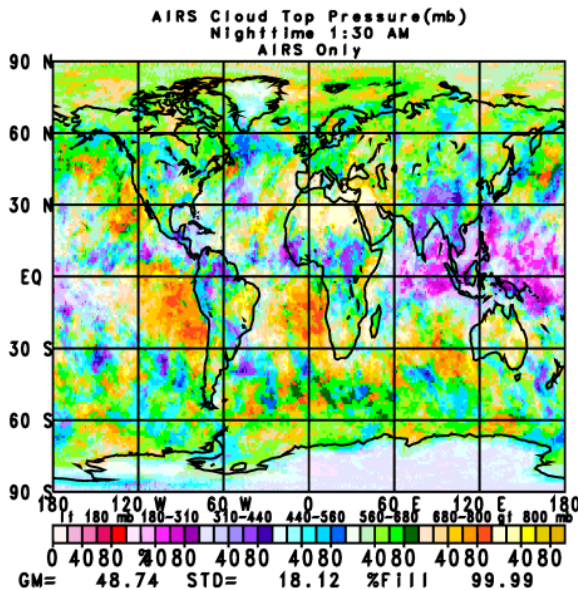
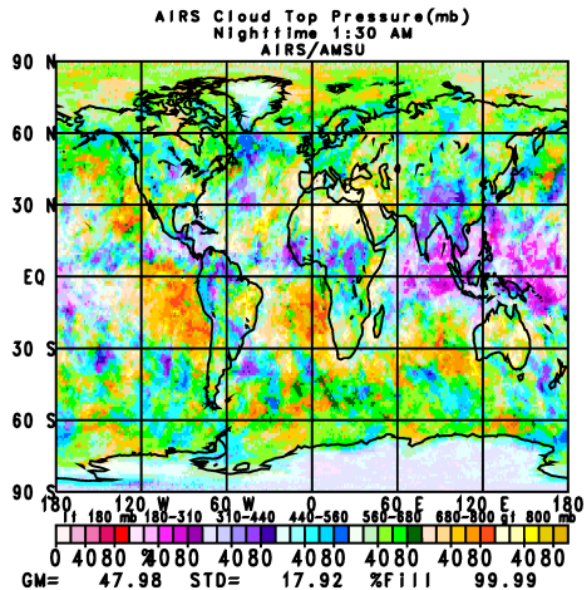
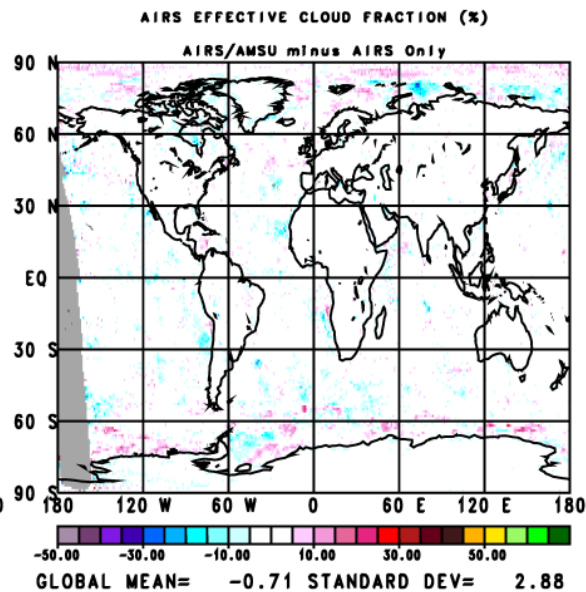
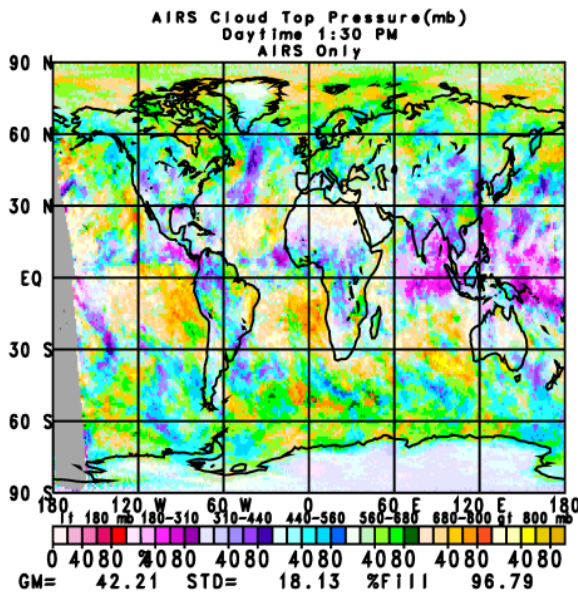
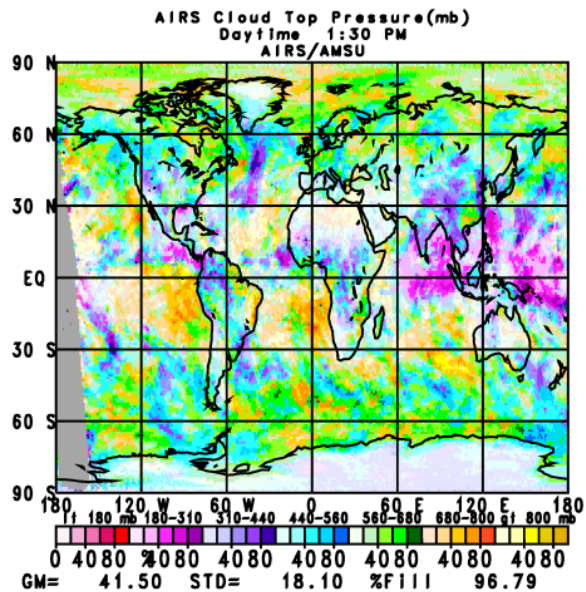
# Back-up Material

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- Comparison of 7-day mean V5.9.12 Level 3 products with V5.9.12 AO
- All results are extremely close with each other
- V5.9.12 AO total precipitable water is slightly poorer over ocean as a result of loss of AMSU-A2 23.8 GHz and 31.4 GHz channels

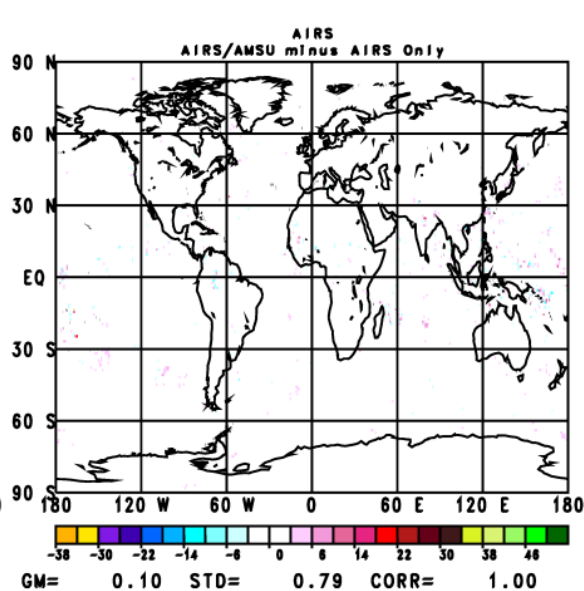
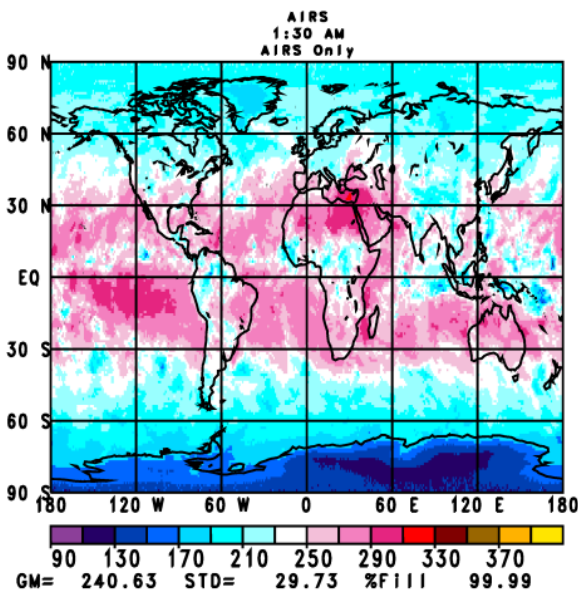
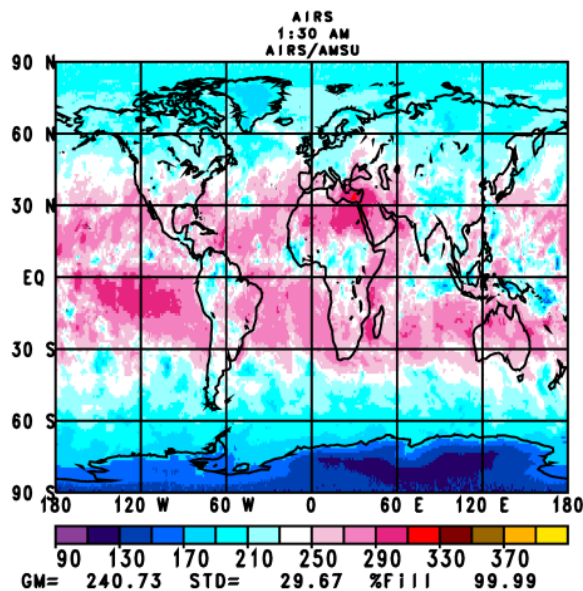
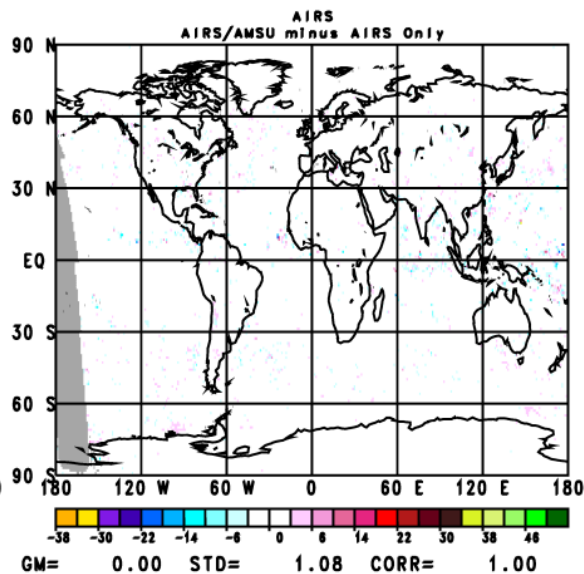
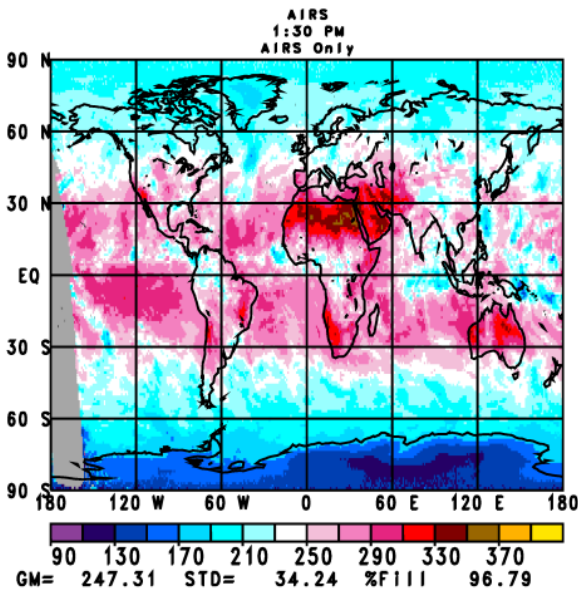
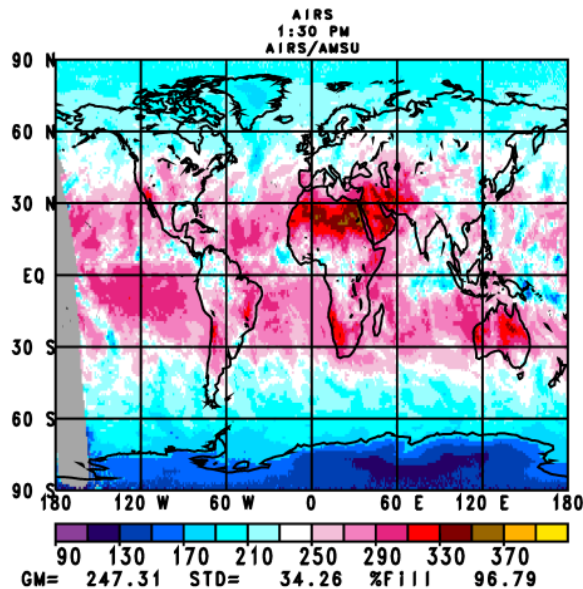


# Cloud Parameters 7-Days V5.9.12 Old Water Channels AIRS/AMSU vs AIRS Only

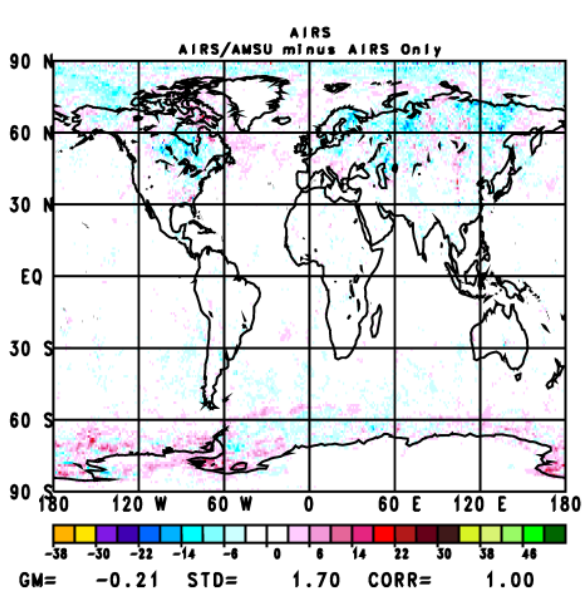
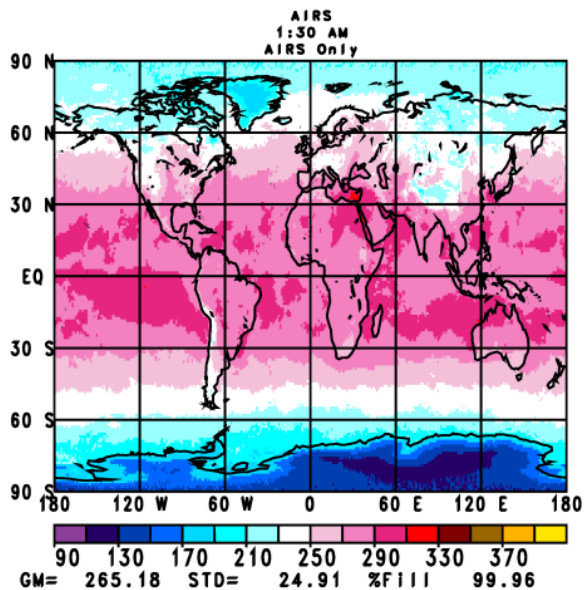
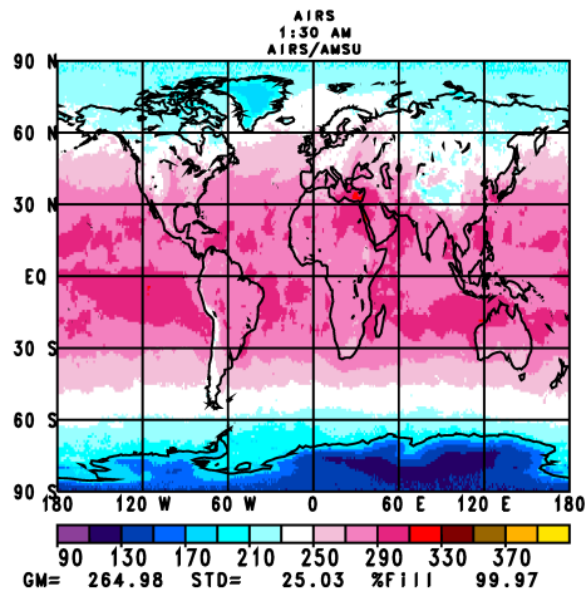
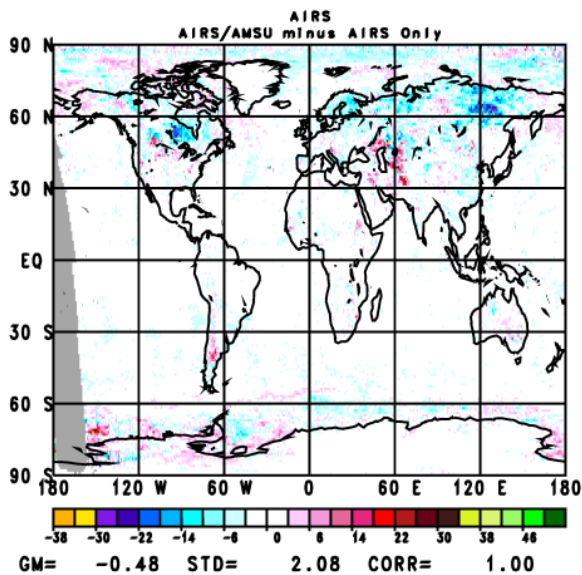
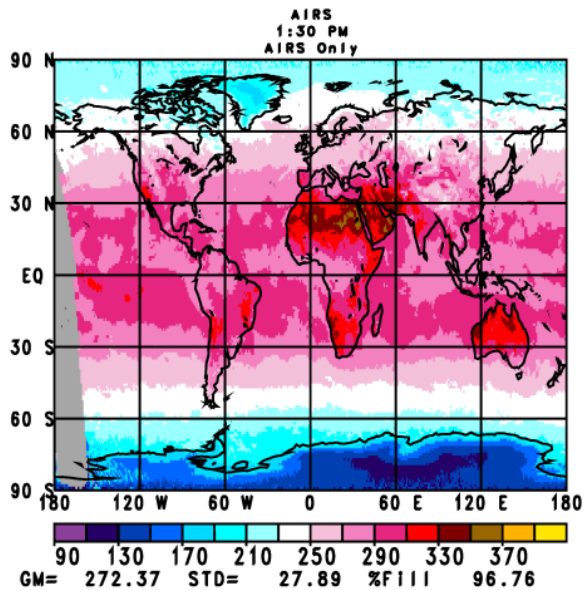
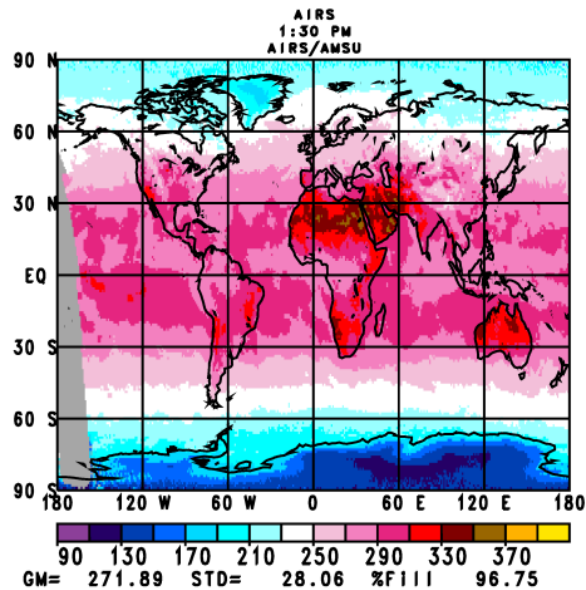




# Outgoing Longwave Radiation (Watts/m<sup>2</sup>) 7-Days V5.9.12 Old Water Channels AIRS/AMSU vs AIRS Only

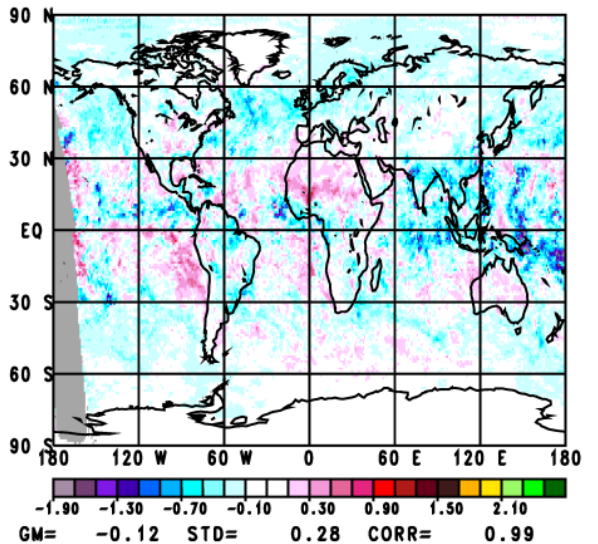
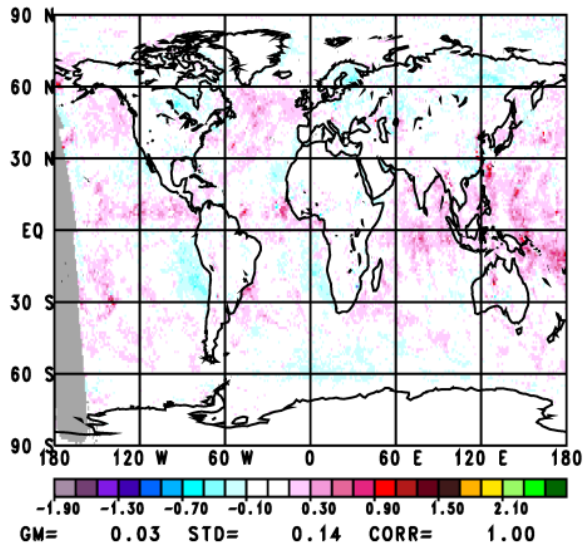
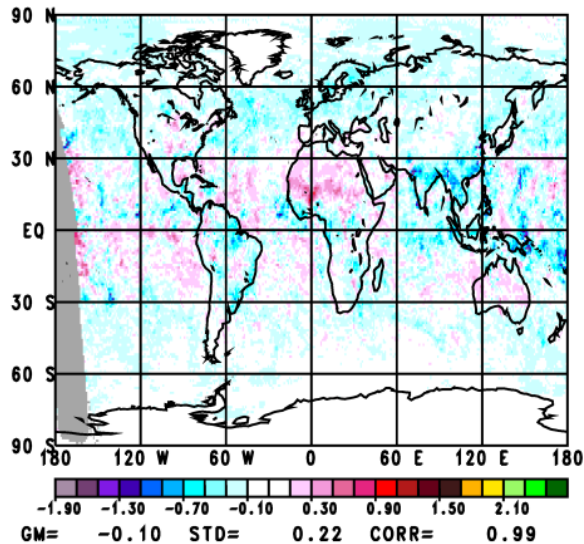
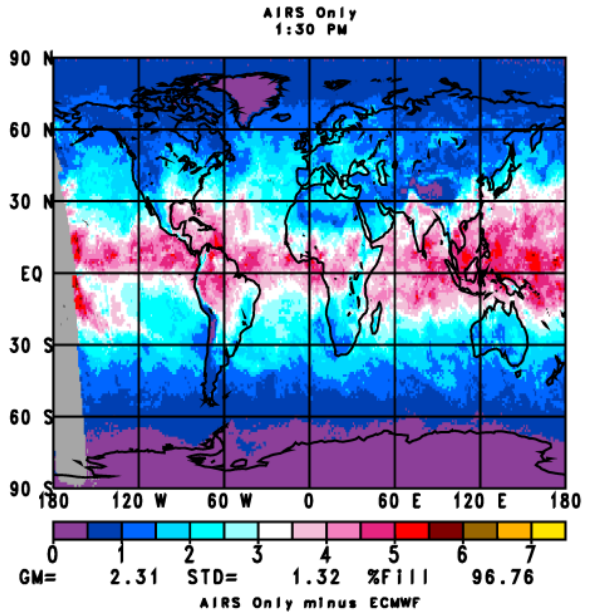
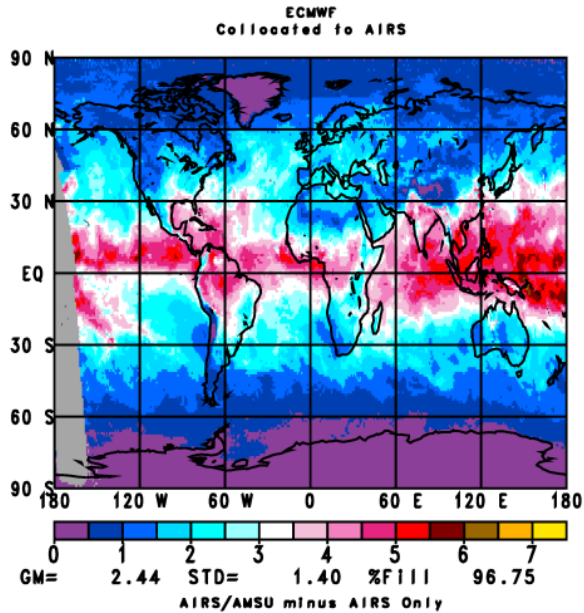
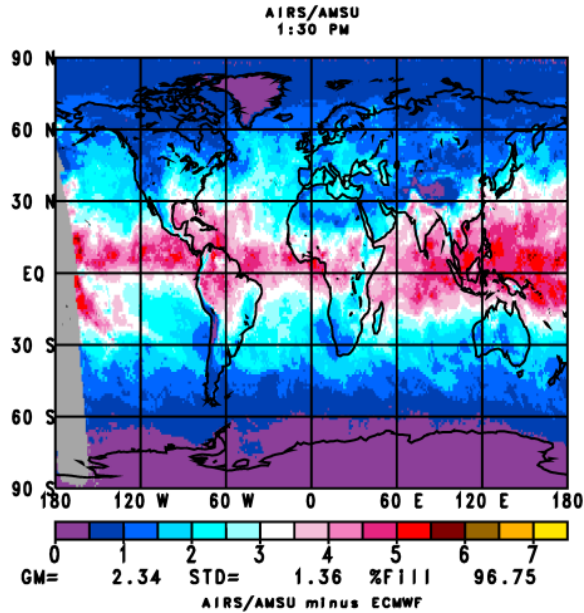


Clear Sky OLR (Watts/m<sup>2</sup>) 7-Days  
V5.9.12 Old Water Channels  
AIRS/AMSU vs AIRS Only

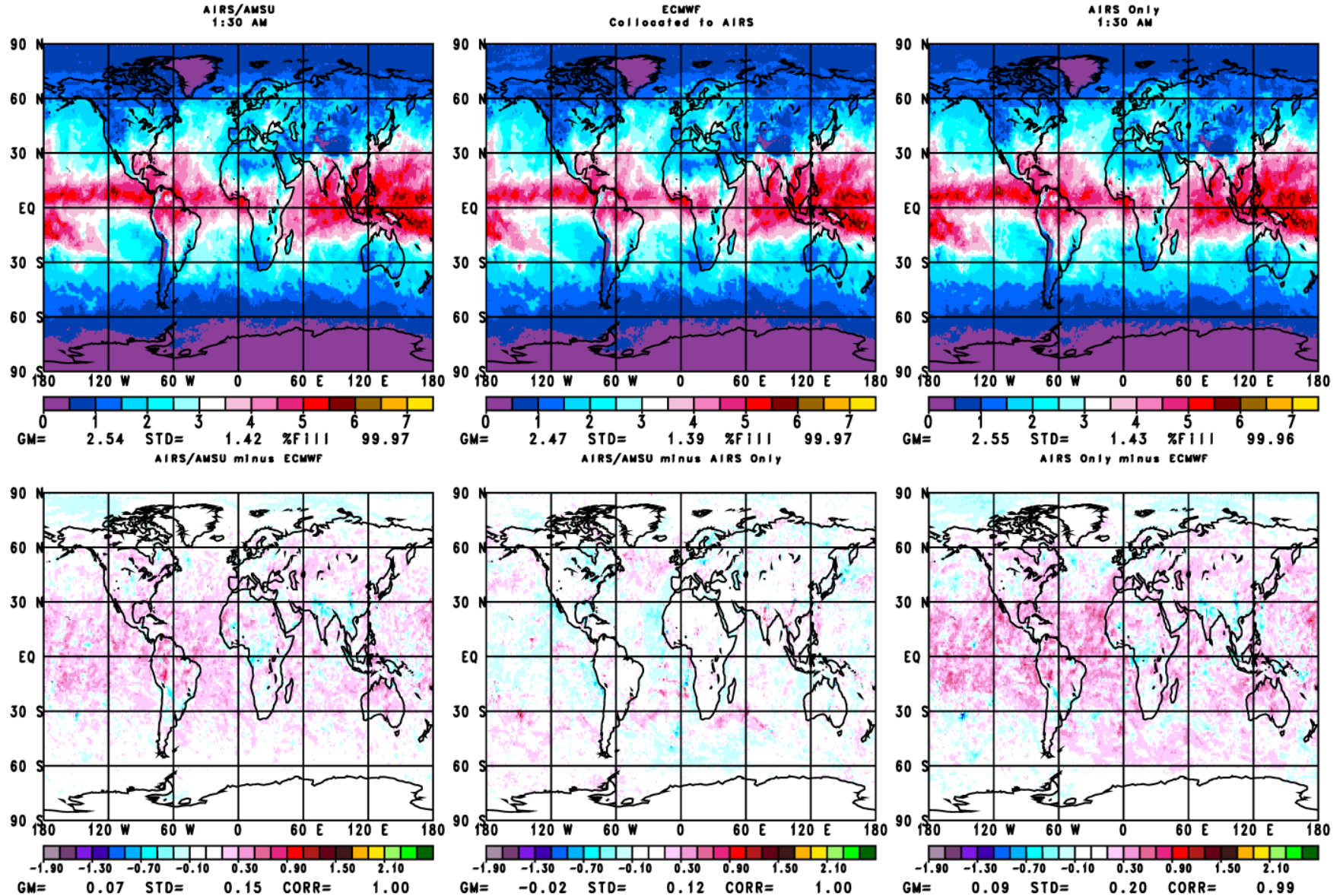




# Total Precipitable Water (cm) 7-Days V5.9.12 Old Water Channels AIRS/AMSU vs AIRS Only



# Total Precipitable Water (cm) 7-Days V5.9.12 Old Water Channels AIRS/AMSU vs AIRS Only





Trace Gases CO  
V5.9.12 Old Water Channels  
AIRS/AMSU vs AIRS Only 7-Days

